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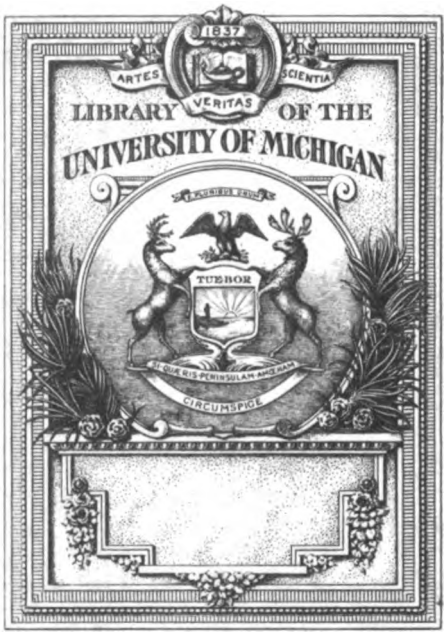
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INDUSTRIAL ENGINEER

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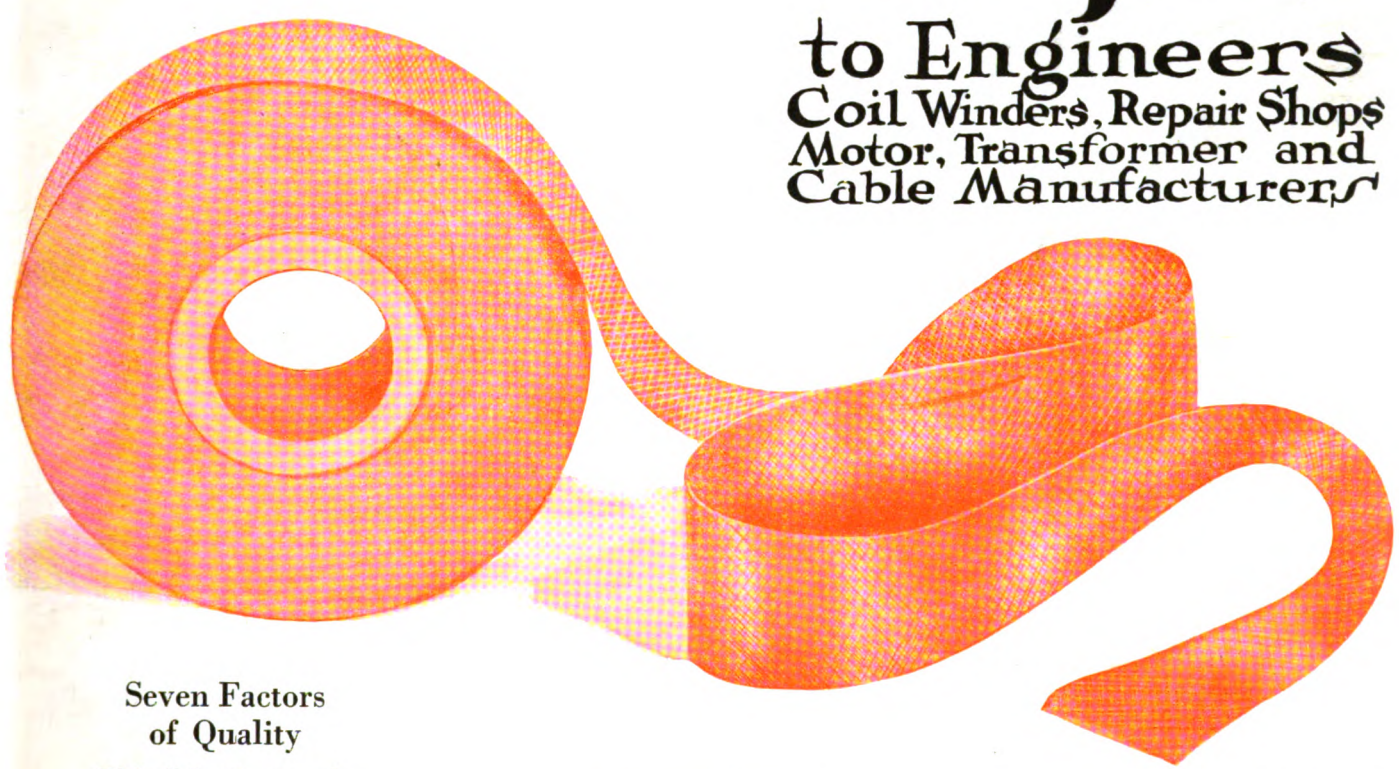
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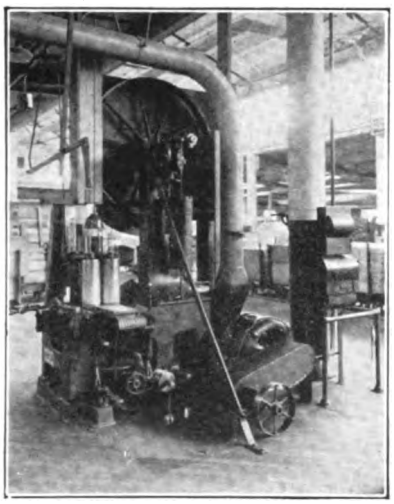
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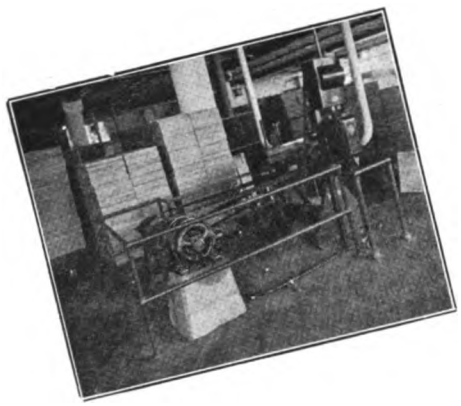
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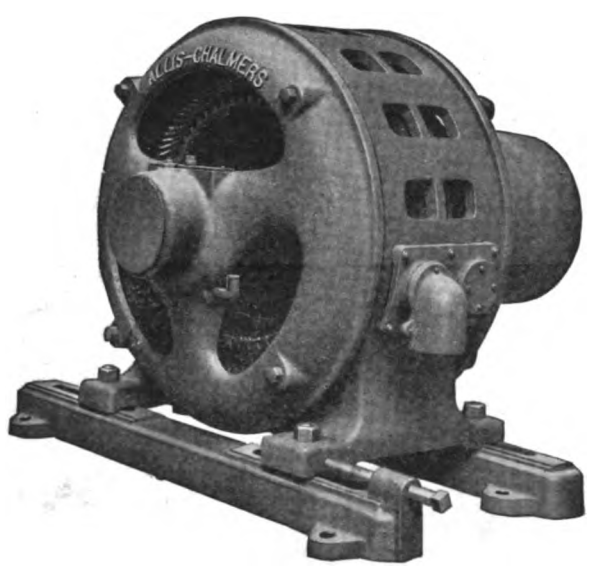






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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 | Chicago, January, 1923 | *Number 1*



This Certificate of Appreciation

Has Struck Deep Down Into My Being Because Of the Understanding it Reveals of an Aim and a Purpose

DURING the past week we have all realized again the meaning of Christmas because we have seen the reaction of the mind of the child to the spirit of giving and all of us, whether we have known it or not, have experienced again the days of our childhood when the strife of this world of ours was an experience unknown and we expressed uncontrolled appreciation of the little things because they were a part of the spirit that is everywhere at Christmas time.

On December 24 I listened in through my radio headset to a sermon broadcasted from the Central Church of Chicago, which had for its theme the "Meaning of Christmas" and I took away two lessons that we can all learn. The first is that the spirit during Christmas time more than any other is a "Peace on Earth Among Men of Good Will." Peace not among jealous, ambition-aspiring and inwardly selfish men who see nothing good in the other fellow, but Peace among men of good will. The second is that although we have learned how to control and make use of almost all the physical forces of nature, we are totally ignorant of how to control and make use of the thing among men which expresses itself in good will.

And while I was listening in I heard a recital of this conversation between the head of a large corporation and a visitor who inquired how such a spirit of loyalty was created in his organization. The answer came when a call button was pushed by the executive and a young man walked in. To the question, "How long have you been with this company?" he answered, "Three years." Then he was asked, "Are you a stockholder?" and he replied with a smile of satisfaction, "I am." And finally he was asked, "How long do you expect to stay with us?" and the answer came without the least of hesitation, "I expect to stay with this company the rest of my life." Turning to his visitor, the executive of that company said: "You have heard from a boy with whom I have never talked before, the answer to your question—how we created loyalty in our organization. We don't create it; it grows from the fact that our men work with us, not for us, and we look for the opportunity to commend such spirit as this boy has displayed."

And so after twelve months of service with the readers and editors of this publication, I have selected from the many kind things that have been said, an expression from a reader who has not praised what I have furnished in way of usable information but an understanding of the spirit and the feeling I have tried to show in what I have written. He has found the key to good will among men that brings peace on earth and I am ready to say that I have a stock interest in the work of such men that will serve as an unwritten contract for my services with them and for them the rest of my life. Mr. Bonds, I thank you!

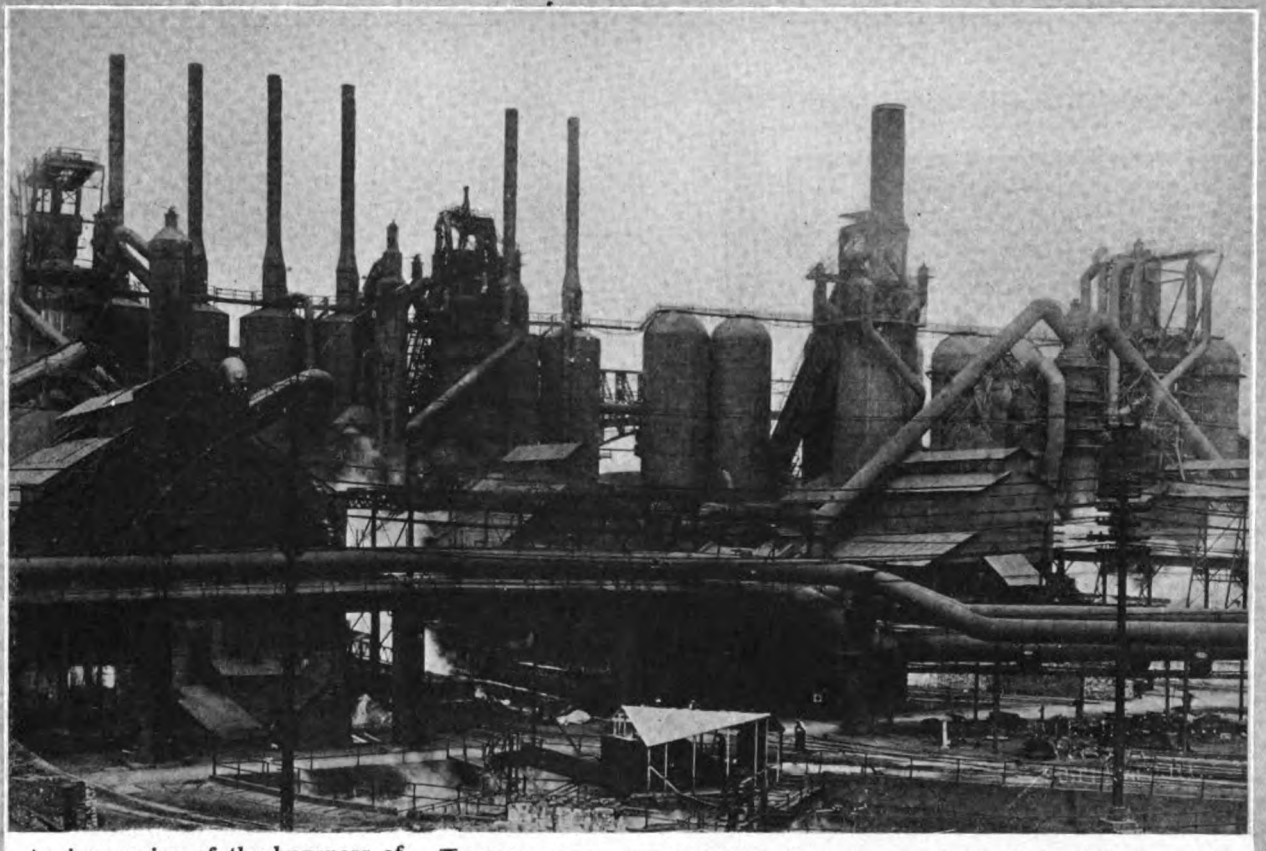
Practical Pete

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A Glimpse Into the

Works of the U. S. Steel Corporation

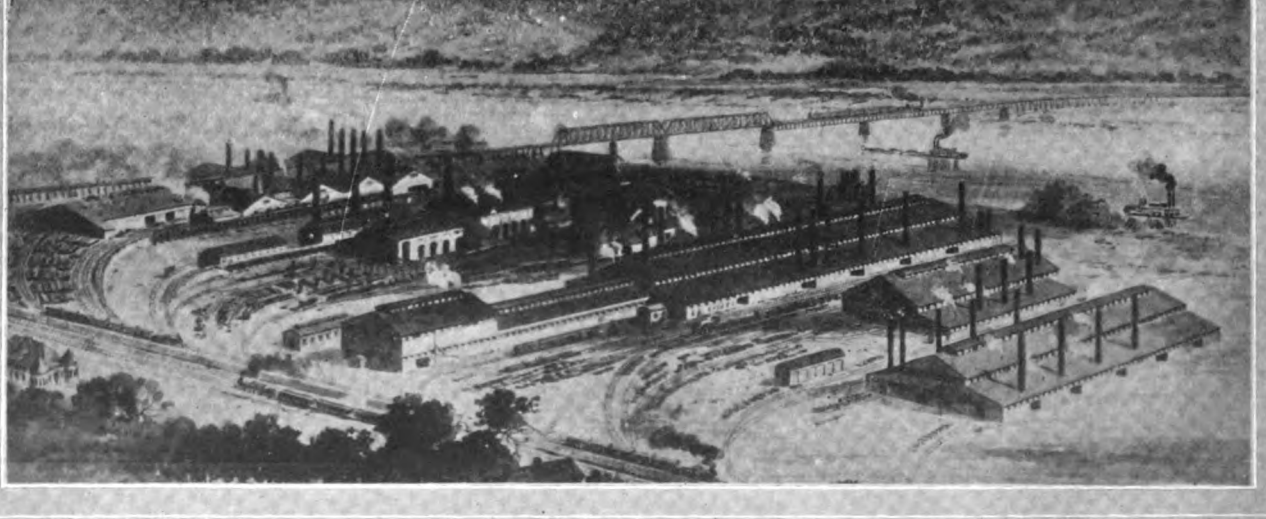
This is the first of a series of short articles that will give a mental picture of the growth and extent of manufacturing works that form the backbone of this country's industrial activity.



An impression of the hugeness of a steel plant's operations is received from these blast furnaces of the Illinois Steel Company.

Below is the Homestead Works of the Carnegie Steel Company as it looked in 1890. It is now a part of the United States Steel Corporation.

INDUSTRIAL ENGINEER will present each month hereafter a series of pictures of the beginnings and present size and extent of those industrial works of this country on which some 290,000 manufacturing establishments depend for raw materials, supplies and machinery. These key industrial works stand as monuments of things accomplished by groups of men; department heads and their assistants, engineers and executives, whose importance ranks in this order. For on the successful execution of the work involved and the working out of the ideals and plans as a base, stand these monuments to broad vision and accomplish-



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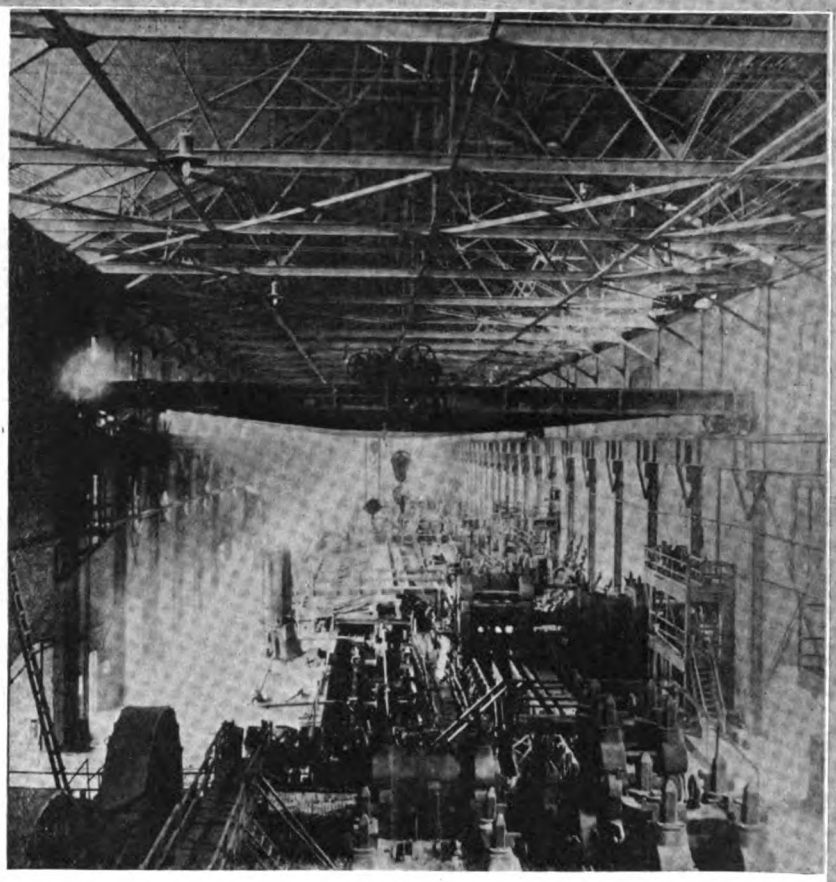
ments of the leaders in all our great works. Men close to the details of operations have made and are making these works what they are and they should be proud of the part they are taking in it, be it ever so humble.

THE United States Steel Corporation has been called a "genial giant." Its products form the backbone of many other American industries.

The story of the steel industry of America is dramatic. In 1845 the first blast furnace was built in this country and in 1881 there were only thirteen steel plants in America. Realizing this, we can appreciate the growth of this great corporation which now operates 142 plants and had a total output of over 14,000,000 tons of finished steel products in 1920. Going back again to the beginning of the iron and steel industry, we find that the first bar of iron was rolled in the United States in 1817. The first puddling furnace was installed in Boston in 1825. It was not, until 1845, however, as already mentioned, that the first blast furnace was put into use and in 1861 the first Bessemer converter was installed. In 1865 at the North Chicago plant of the Illinois Steel Company, now a part of the United States Steel Corporation, the first steel rail in America was rolled. The open-hearth furnace came in 1869.

It was after 1890 that the industry began its tremendous expansion. In 1901 two of the largest companies, the Illinois Steel and the Carnegie, combined and took in a number of other companies to form the United States Steel Corporation. Though the number of plants embraced in this corporation was practically the same as it is now (142 in 1922) the output in steel products in 1922 was almost double that in 1901. The number of blast furnaces has increased from 73 to 124. Moreover, the output of valuable by-products has increased enormously; for instance, cement from 162,000 bbl. to 12,500,000 bbl. and benzol from zero to 45,000,000 bbl. It is true also that the price of steel per ton actually decreased until the war period although most other products increased in price.

At the present time the United States Steel Corporation operates 142 plants that produce steel products and cement, sixteen subsidiary companies, sixty-five coke plants, sixty separate coal mines, ninety-six ore properties, one hundred and twenty-three steamships and three hundred and thirty other vessels, eight railroads with almost 1,000 miles of main line, besides dock, water-supply systems, gas and oil properties.



From one end of the rail mill above to the other is about as far as the eye can see.



This railroad yard of the Illinois Steel Company covers an area as large as a small city.

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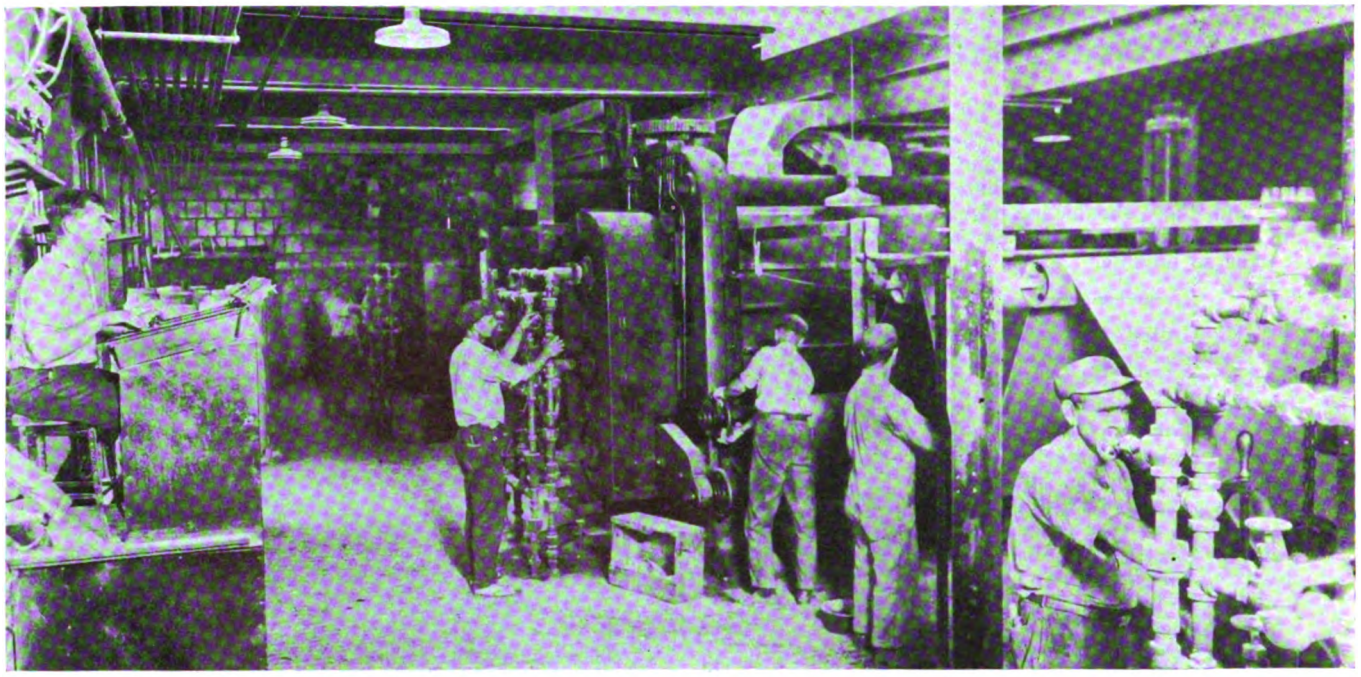


Fig. 1—Here three calender mills are operated as one mill. The speed of the individual motors is controlled (see Figs. 9 and 10) by the man at the desk through three sets of push buttons.

Some Details in The Application of a

Bonus on Operation and Maintenance

Whereby Foremen Are Rewarded According to Economies They Can Show in Maintenance and Power Costs

By A. A. FRANK

Factory Manager, The Federal Rubber Company, Racine, Wis.

ALTHOUGH FOREMEN and others in charge of shop operations are expected to give full attention to all details of supervision in their departments, human nature is such that there is a tendency to stop at "good enough" when a certain degree of achievement is attained, unless there is some incentive to do better. Comparatively few supervisors can drive themselves to do their best at all times. These few are most often found in the higher executive positions such as assistant superintendent, superintendent, president or some of the other members of the organization who carry the responsibility for production.

In general, there are three methods of getting a foreman (or a workman either) to do his best: (a) By driving; (b) by appealing to his pride or prejudices, his likes and dislikes; and, (c) by giving him a financial incentive, preferably graduated so as to increase with increased effort.

In the operation of these methods, men—foremen as well as workmen—

WHERE THERE is little incentive to do otherwise men are inclined to drift into a humdrum routine in handling the jobs assigned to them without doing much thinking. This is no criticism; it's human nature. Under the bonus plan, described in this article, the men in responsible positions are wide awake and think ahead because the extra money they can earn makes this worth while. The first year this plan was in operation in the works of The Federal Rubber Company at Racine, Wis., the total annual production cost was reduced 5 per cent.

resent driving. While they will do more for the "pat on the back" and the compliment of the second method, they often feel that they are not rewarded for the extra effort put forth while the company or the executive above them benefits from it. Usually the greatest satisfaction and best results come from sharing in some form of bonus, the additional profits or savings resulting from closer attention or effort. It is necessary, however, to fix the starting point on some definite standard or task and at an attainable figure so that the men are not discouraged by never earning a bonus. The reward should then increase as greater savings are made.

Rubber work, particularly the manufacture of automobile tires, lends itself to sufficient standardization to fix definite requirements or tasks as the basis of the bonus. In establishing the bonus plan at The Federal Rubber Company's plant, some of the following factors are used in determining the bonus basis

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Fig. 2—Bonus Standard in Electrical Department

For Class B Foreman

Item	Importance	First		Second		Third	
		Task	Bonus	Task	Bonus	Task	Bonus
Repair cost in factory per 1,000 lb. stock delivered from the mill room.....	45%	Standard*	$22.50	19% decrease	$45.00	38% decrease	$67.50
Total kw.-hr. per 1,000 lb. stock delivered from the mill room.....	25%	Standard*	12.50	15% decrease	25.00	30% decrease	37.50
Direct overhead of Electrical Dept.....	10%	30%	5.00	25%	10.00	20%	15.00
Authorized labor — labor hours estimated on new installation.....	20%	100%	10.00	95%	20.00	90%	30.00
	100%		$50.00		$100.00		$150.00

*—Instead of actual figures this table calls the first task the "Standard" and then gives the percentage by which this standard must be decreased to make the second and third tasks. The foreman, however, knows the standard and also receives a report showing the record for the three months period.

Fig. 2—A sample task and bonus as applied to the foreman of the Electrical Department.

Similar standards are worked out for other foremen on bonus. This shows what the foreman must do—his task—and what he will earn—his bonus—by doing it. He is paid according to his accomplishments and may earn third bonus on some of the four items and a lower one or even fail on others.

for the foremen and assistant foremen. The bonus for *Production Departments* is based on a different set of factors than is used in determining the *Maintenance Departments'* bonus. The seven factors are:

1. Percentage of "seconds" and rejections.
2. Cost of repairs to imperfect products.
3. Percentage of waste per unit.
4. Departmental unit cost of production.
5. Materials consumed, based on production.
6. Amount of power used per unit.
7. Direct overhead costs.

In establishing this bonus two factors incidental to the industry help to establish the basis of the task. These are: (1) The cost of material is approximately 65 per cent of the cost of the finished product. (2) One definite unit, the amount in thousands of pounds of rubber stock delivered from the *Mill Room* governs the fluctuation of activity in practically all the other departments. The first factor is of principal importance in all manufacturing departments where the big savings lie in the decrease of waste fabric or rubber and in a reduction in the percentage of "seconds," of rejections and in the cost of repairs necessary to make imperfect products usable as a low grade.

The trimmed waste in each department is weighed up each night and charged against the department. It should not exceed a certain amount and is generally specified as a definite number of ounces allowed per tire or a certain percentage by weight of rubber or fabric handled. The bonus depends upon the amount of the reduction below this allowance. The other factor, the output from the *Mill Room*, is used as a basis for determining the amount of power which should be used and the bonus for the repair and maintenance work—factors which fluctuate according to the activity of the whole plant. Every 1,000 lb. of rubber stock going through the mill room means a fairly definite amount of work and power consumed in each succeeding department.

Tasks and Bonus in Electrical Department

To provide an incentive for increased effort, the bonus is graduated into first, second and third tasks, with a definite standard and bonus payment set for each. The three tasks and the bonus payments for each which may be earned by the foreman of the *Electrical Department*, are given in the accompanying table, Fig. 2. One feature of this bonus plan is that a foreman can earn what he accomplishes in each of the separate tasks. That is, he may earn third bonus in some items making up the bonus, while in others he makes lower tasks or even no task. The bonus is computed on his standing over a period of three months and, as shown in this table, will enable the foreman of the *Electrical Department* to earn $150 extra every three months providing he can make third task in each of the four items determining his bonus. He may make as low as $5 or even nothing.

The first item, "Repair cost in factory per 1,000 lb. stock delivered from the *Mill Room*," is considered as of 45 per cent importance in determining the bonus. This item includes the total cost of upkeep and repairs of machines and equipment and the expense of lubrication. All repair costs are grouped together for ease in computations even though the *Electrical Department* is responsible for only part of them. The same is true of other departments, mentioned later in this article, which base their bonus upon repair costs. This helps in making each department do its full share as it knows that its earnings depend upon the

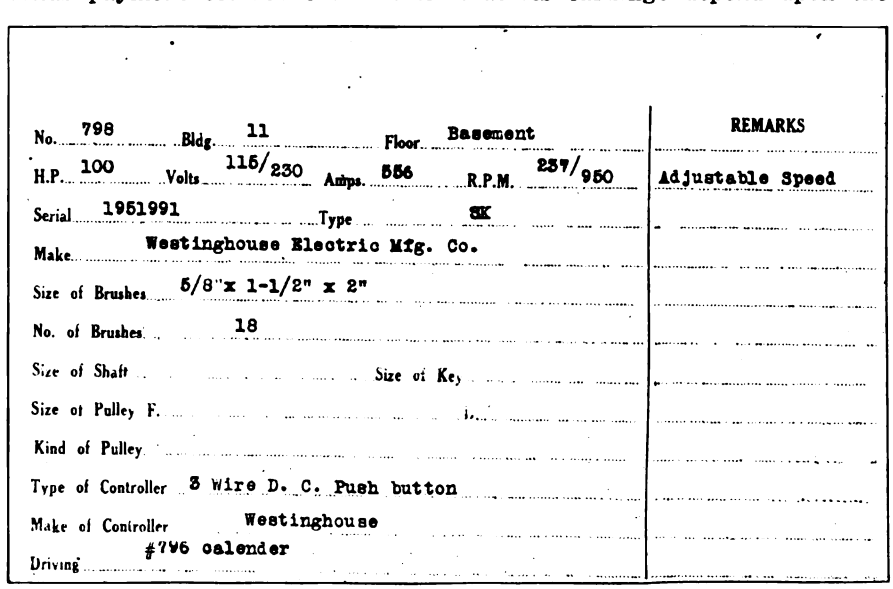


Fig. 3—Each motor has a record card similar to this.

Whenever possible the equipment number and location of other motors which may be substituted for a particular motor are noted on the back of the card. Often a motor can be taken from an idle or less essential machine in an emergency when no substitutes are on hand.

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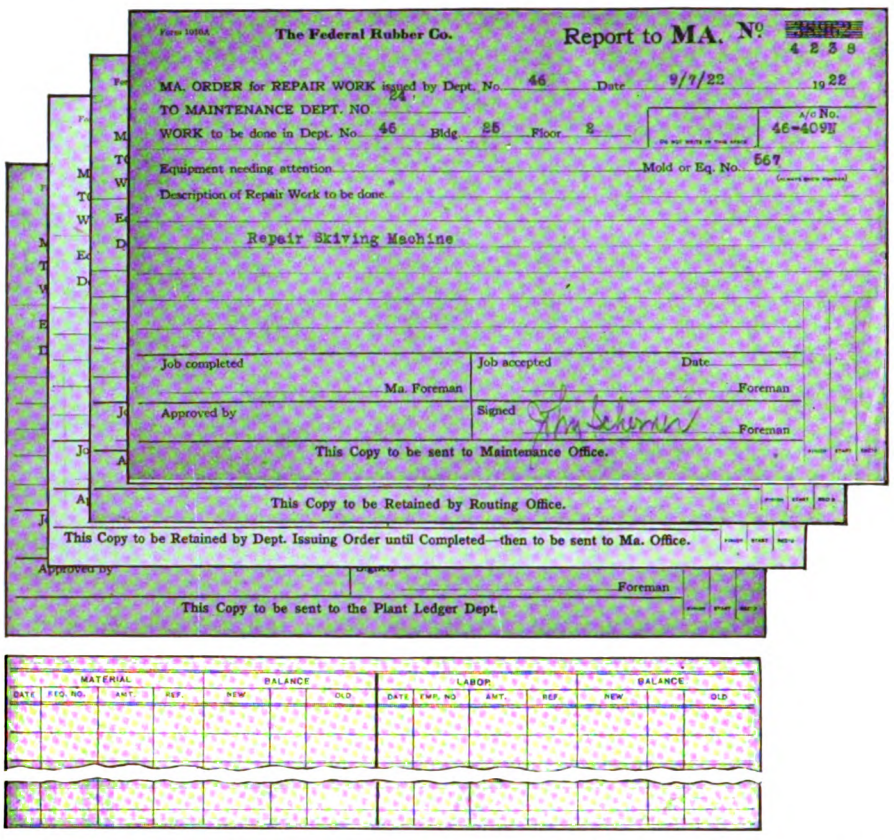


Fig. 4—How ordinary repairs or maintenance work is ordered and the labor costs gathered.

Copies of MA (maintenance) orders are made out in quadruplicate by the department where work is to be done. All copies are sent to the MA department, where they are numbered consecutively as they come in. The pink, or fourth copy, which is on a light card, is sent to the Plant Ledger Department for record and on the back of it is then posted the labor and material so that when the entire job is done the cost of the job is permanently recorded. The back of this card is shown broken. The white or third copy is returned to the originating department for its record. The blue (second) and yellow (original) copies are kept in the MA department until the work is completed. The number of hours on the job are entered on the back of the yellow copy and when the work is done this copy is sent to the foreman of the department where the order was issued, for his approval. Any question can then be taken up with the MA department at once. If O. K., the foreman signs on the line indicated "Job Accepted." It is then returned to the MA department which in turn sends it to the Plant Ledger Department. This is the final closing. The white copy is kept in the MA department files with any notations the Maintenance Department may desire to keep entered on the back. These are analyzed periodically as explained in the article.

efforts of all and that one department cannot save by shirking a little and forcing another department to do some of its work. Also each looks out for the other; an electrician will report a warm bearing or an oiler a sparking motor. Grouping of tasks thus practically forces the different departments to work together.

The second item, "Total kw.-hr. per 1,000 lb. stock delivered from the *Mill Room*" is rated as of 25 per cent importance in determining the bonus for this department. The *Electrical Department* foreman, while he has no direct supervision of the operation of the machines and motors in the various *Production Departments*, is responsible for the proper application of a motor and also for the inspection and upkeep of the various motors in all departments. If a motor is over- or underloaded it is up to his department to find it out and remedy it.

On the large motors, as in the *Mill Rooms* where approximately 90 per cent of the power is used, the mills are run idle at least once in each three months to see if the friction loss of the equipment is increasing. Here five or six mills (Fig. 11) are driven through gearing from pinions on a long shaft which in turn is connected through a reduction gear to a 400 or 500 hp., 2,300-volt motor. There are no clutches in the line and so all machines in the group are operating whether loaded or running idle. This grouping permits the motor to take care of any fluctuations in the load which might give a momentarily heavy overload if each mill had its own drive. The friction loss on these mills is of great importance as even under the best conditions the mills when running idle use about half the power consumed when running loaded. Any increase in this friction loss adds considerably to the power consumption. An indicating ammeter mounted on the motor control-board in the basement (Fig. 12) shows the fluctuation in power as the mill is operating and by observation the electrician can usually spot any unusual increase in total consumption without making the no-load tests. This gives him a quick indication that something is wrong.

In addition, the electrical department changes brushes and periodically cleans the motors and switchboards which become covered with the powdered soapstone used in the milling process. In the *Mill Rooms* this is blown out each Sunday when the equipment is "dead," as the compressed air contains too much moisture to risk using on 2,300 volt equipment when it is "alive." One electrician and his helper work nights. The helper cleans and oils and the electrician makes necessary repairs on day motors and any emergency night repairs.

Any reduction in the direct overhead of the department, the third item determining the bonus, is largely on the responsibility of the foreman and is rated at 10 per cent in importance. Overhead is figured on direct labor. Its reduction is largely a matter of supervision.

"Authorized labor," the fourth item, is the labor applied in the construction or erection of any new or permanent work such as a new lighting system or the wiring for a new motor. Any work which will cost more than $100 must be authorized by some official and a careful estimate made of the cost and the results expected before it can be started. This authorization report is made out as shown in Fig. 5. If the foremen (most jobs costing over $100 involve more than one *Maintenance Department*) keep within the estimate they earn the first bonus; if they go below 95 per cent, they earn the second bonus; and, if below 90 per cent, or 10 per cent saved, the third bonus. The workmen in the various maintenance and repair gangs share in this by earning as a bonus pay for one-half of the hours saved in addition to their regular wages.

In determining whether or not a bonus is made on authorized labor, the labor-hours are not subdivided and credited against the separate *Maintenance Departments*, if two or more are involved on any job, but the net result is used as a basis. Thus one department may have

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gained but if the others lose more than was gained only the net result is used. The bonus is determined according to the net standing over a three-months' period instead of by individual jobs. This plan of grouping also tends to make all departments and gangs work together since they have a common purpose.

Bonus Plans in Other Maintenance Departments

Other department foremen, besides those engaged in production, who receive a bonus are the foremen of the *Pipe Shop, Machine Shop* (outside maintenance work) and *Machine Shop* (inside shop work), the general foreman over both *Machine Shop* foremen, the foremen over *Maintenance Inspection* in charge of oiling, etc., and *Carpenter and Box Shop,* and the general foreman and day and night foremen of the *Power Department.* In addition, the superintendent of maintenance, who has charge of all except the *Power Department,* receives a bonus which is based upon the bonus earned by the departments under his direction. He also has supervision over the yards and sewers but the foreman on this work, however, is not on a bonus.

All foremen are rated or classed according to their importance; the superintendent of maintenance is a Class AA man, the general foremen of *Power* and of the *Machine Shops* are Class A men, the foremen are Class B men, and the assistant foremen are classified as Class C or D men. Generally the bonus in each class is 75 to 80 per cent of the bonus of the next class higher.

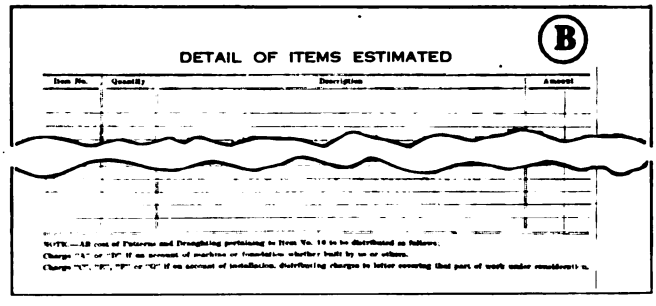
It will be interesting to go over the items making up the bonus in some of these departments and see how their work is closely related to the selection of the items. For example in the *Pipe Shop,* which does all new and maintenance work on the steam, water and air lines, the kilowatt-hours used are not taken into consideration as work of this department does not affect this item. Here three points are considered which, with their importance, are as follows:

1. Repair cost per 1,000 lb. from Mill Room....50 per cent
2. Department overhead....20 " "
3. Authorized labor.....30 " "

These three items are used also in determining the bonus of the foreman of the *Machine Shop* (inside shop work) and of the *Box and Carpenter Shop.* As each of these two has inside work where closer supervision may be given to the overhead and they are still less closely connected with the responsibility for outside maintenance, the importance of the three items is changed to a new ratio of 45, 25 and 30 per cent. A large share of the work in this *Machine Shop* consists of building and repairing tire molds and cores

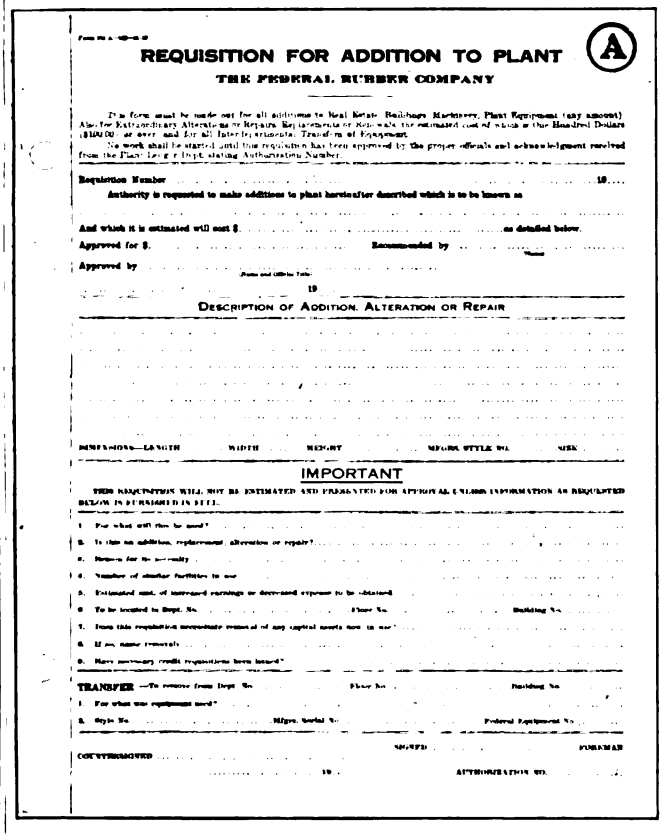
Fig. 5—Requisition for additions and extensive alterations or repairs.

All additions to the plant, machinery or equipment, and extraordinary alterations, replacements or renewals, which it is estimated will cost over $100, as well as interdepartmental transfers of equipment, are requisitioned on this form. It is then approved and authorized by some official of the company before work can be started. The labor involved is called "authorized labor" (Fig. 2) and is one item in determining the bonus of Maintenance Department foremen who have responsibility for construction and maintenance work. On the second page (B) is a detailed list of materials for the job. The fourth page is blank for sketches or additional entries. When costs of new work are carefully estimated in advance there is less likelihood of making an unwise move. Departments receive this bonus on the reductions of "estimated" hours of labor by the group of Maintenance Departments.


B

DETAIL OF ITEMS ESTIMATED

Item No. | Quantity | Description | Amount


A

REQUISITION FOR ADDITION TO PLANT

THE FEDERAL RUBBER COMPANY

Requisition Number ..... 19....

Authority is requested to make additions to plant hereinafter described which is to be known as

And which it is estimated will cost $ ..... as detailed below.

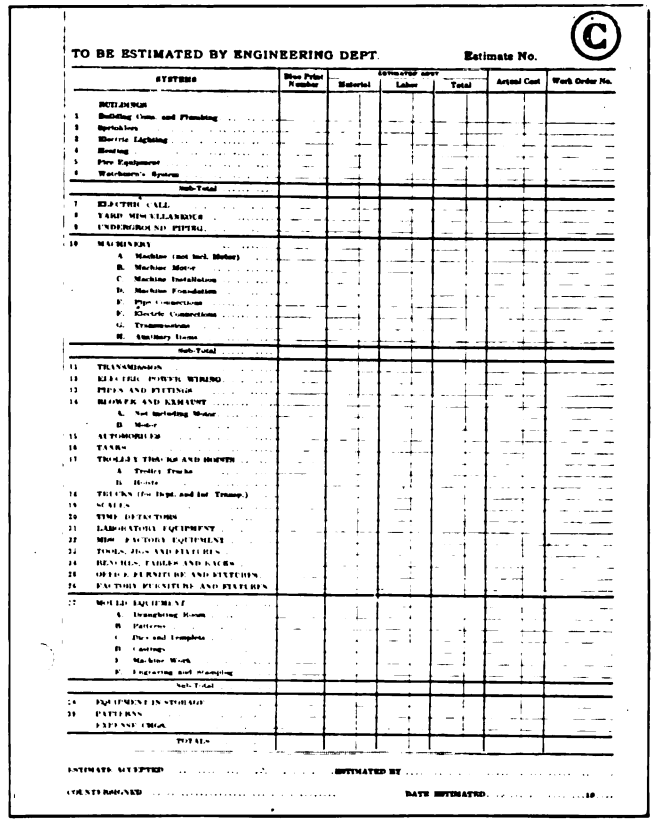
Approved for $. ..... Recommended by .....

Approved by .....

19

DESCRIPTION OF ADDITION, ALTERATION OR REPAIR

IMPORTANT


C

TO BE ESTIMATED BY ENGINEERING DEPT. Estimate No.

SYSTEMS | Blue Print Number | Estimated cost: Material | Labor | Total | Actual Cost | Work Order No.

BUILDINGS
1 Building Outs and Plumbing
2 Sprinklers
3 Electric Lighting
4 Heating
5 Fire Equipment
6 Watchman's System
Sub-Total

7 ELECTRIC CALL
8 YARD MISCELLANEOUS
9 UNDERGROUND PIPING

10 MACHINERY
A Machine (not incl. Motor)
B Machine Motor
C Machine Installation
D Machine Foundation
E Pipe Connections
F Electric Connections
G Transmissions
H Auxiliary Items
Sub-Total

11 TRANSMISSION
12 ELECTRIC POWER WIRING
13 PIPES AND FITTINGS
14 BLOWER AND EXHAUST
A Not including Motor
B Motor
15 AUTOMOBILES
16 TANKS
17 TROLLEY TRACKS AND SWITCHES
A Trolley Tracks
B Hoists
18 TRUCKS (for Dept. and Int. Transp.)
19 SCALES
20 TIME DETECTORS
21 LABORATORY EQUIPMENT
22 Misc. FACTORY EQUIPMENT
23 TOOLS, JIGS AND FIXTURES
24 BENCHES, TABLES AND RACKS
25 OFFICE FURNITURE AND FIXTURES
26 FACTORY FURNITURE AND FIXTURES

27 MOLD EQUIPMENT
A Draughting Room
B Patterns
C Dies and Templets
D Castings
E Machine Work
F Engraving and Stamping
Sub-Total

28 EQUIPMENT IN STORAGE
29 PATTERNS
EXPENSE CHGS.

TOTALS

ESTIMATE ACCEPTED ..... ESTIMATED BY .....

COUNTERSIGNED ..... DATE ESTIMATED ..... 19....

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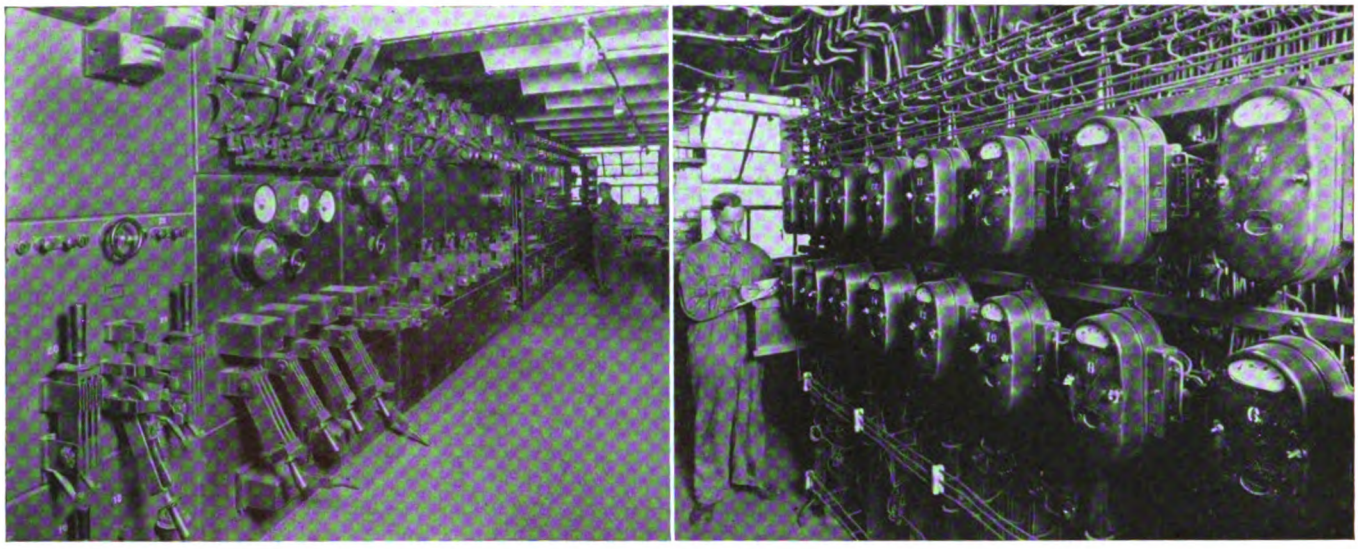


Fig. 6—Main switchboard in Power Department.

At present electrical energy is purchased but the generating equipment is retained for emergency service. The section at the far end contains the meters for the individual Production Departments.

for production processes although any necessary maintenance construction, rebuilding of machines, or new work which it is fitted to do is carried on also. The *Box and Carpenter Shop* makes wood patterns for casting molds and cores, boxes for exporting tires and any cabinet or carpenter repair work for the plant.

The foreman in charge of *Machine Shop* (outside work, which is more strictly plant maintenance), however, looks after the installation of new equipment, except pipe and electrical work, as well as the general repair and maintenance work and shares in the responsibility for the kilowatt-hours used in production for he is responsible for bad bearings, shafts out of alignment, excessive friction in pinions and gears and other heavy friction losses. The items in his bonus and their importance are the same as given in Fig. 2 for the *Electrical Department* foreman.

Power Department Bonus Based on Boiler Efficiency

Neither the kilowatt-hours used nor the cost of repairs has any influence upon the *Power Department* bonus. Electric energy is purchased and metered (Figs. 6 and 7), to each production department. These meter readings, however, are recorded by the *Power Department*. The items here are:

1. Power department labor hours per ton of coal used .....20 per cent
2. Over-all monthly boiler efficiency .....70 " "
3. Direct department overhead .....10 " "

The labor allowance for first task in handling coal is 1.4 hr.; second task, 1.2 hr.; and, third task, 1 hr. per ton of coal used. This covers the labor from car to bunker storage and the handling of the ashes. Extra labor, such as would be required for moving coal to and from yard storage, is not included. The first task in boiler efficiency is to maintain an over-all efficiency of 64 per cent, the second task an efficiency of 67 per cent and a third task of 70 per cent. The average efficiency over the entire month is used to determine the percentage of attainment instead of taking results of irregular or periodic tests. The departmental overhead is based upon and includes the cost of generation of steam, hydraulic and pneumatic power, of direct current for lighting and for a few motors, transformed by a 2,300-volt synchronous converter, and the office overhead of the power plant. The firemen receive a separate bonus based upon their CO_2 record, and so endeavor to maintain a high boiler efficiency.

Fig. 7—Power consumption of each department is recorded here.

These D-6 General Electric polyphase integrating meters placed on the back of the switchboard are read by the Power Department periodically. Without some means of knowing the power consumed in each department, this organization would not have such careful supervisory control over the production costs nor could it operate the bonus plan as described in this article.

A large share of the maintenance responsibility rests upon the foreman of the *Maintenance Inspection Department* who has charge of the routine inspection and lubrication of all except the electrical equipment. Three oilers are on duty days and one at night. Here, as stated

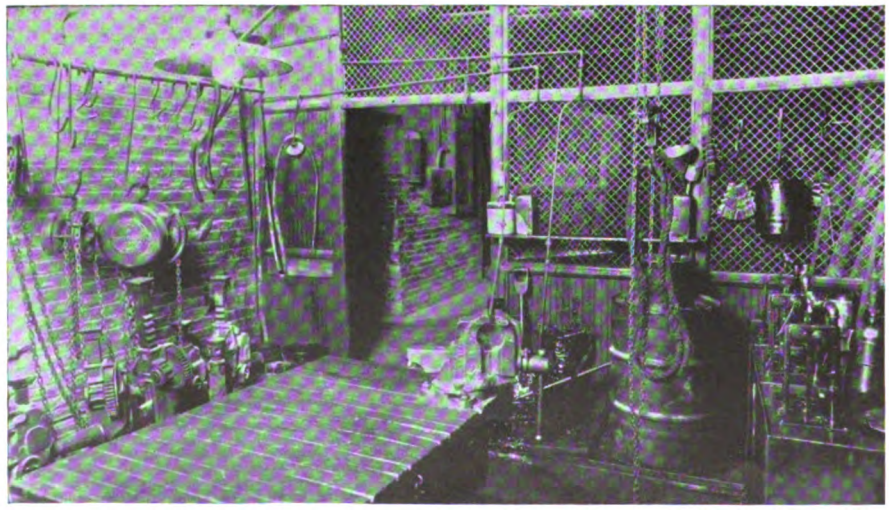


Fig. 8—Maintenance sub-station in one of the Mill Rooms.

This small room is separated from the rest of the department by fire walls and a stairway. The Maintenance Department, which is located at the other side of the plant, stores many of its hoists, jacks and similar heavy equipment where it is close to the heavy machine installations. A bench and vise enable many small repairs or fittings to be made without going the long distance to the Maintenance Department. The oilers fill their oil cans from the storage tanks.

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previously, the men co-operate in reporting difficulties to each other as the bonus depends upon the efforts of the group instead of the individual. The items upon which the bonus is based and the relative importance of each are the same as for the *Electrical Department* foreman as given in the table, Fig. 2.

How the Bonus Is Applied to Production Departments

The foremen and some assistant foremen in the *Production Departments* are on a bonus also but the power consumed is a governing factor only in the *Mill Rooms* where it is based on standards set per 1,000 lb. of rubber stock out of each department. This factor varies with each of the different *Mill Rooms*—the *Main Mill Room* where the rubber stock is milled and calendered for the automobile tires; the *Baby Cab Department*, where solid tires are made for baby cabs, velocipedes, etc.; the *Mixed and Green Scrap Department* where the preliminary working and mixing is done; and, the *Shoddy and Scrap Department* where reclaimed rubber is mixed with scrap and new rubber to be used for making floor mats and similar products which do not require as high-grade rubber stock as tires. Each of these departments is of a different capacity and so each has its own task of standard kilowatt-hour used per 1,000 lb. of stock delivered. These departments, however, are the largest users of power, taking about 90 per cent of all the power used in the plant.

The other items affecting the bonus of the *Milling Departments*, in addition to the kilowatt-hours used, are: Direct overhead and labor costs per unit of production. In the *Milling Departments* the unit is per 1,000 lb. stock delivered. As such a large percentage of the power is used in overcoming the friction of the mills and their heavy gearing, the *Mill Room* foremen's opportunity to save on power, and so earn their bonus, is to see that the mills are loaded as much of the time as possible, and if it is necessary that some be idle to see that the idle mills are all on one group so that the motor of that group may be shut down. Otherwise the whole group of five mills will continue the heavy friction loss even if only one mill is in use.

The other *Production Departments* do not have their bonus based on power used as it is only a small item with them. The large items are waste, "seconds," direct labor and overhead, so the bonus here is placed on such items as:

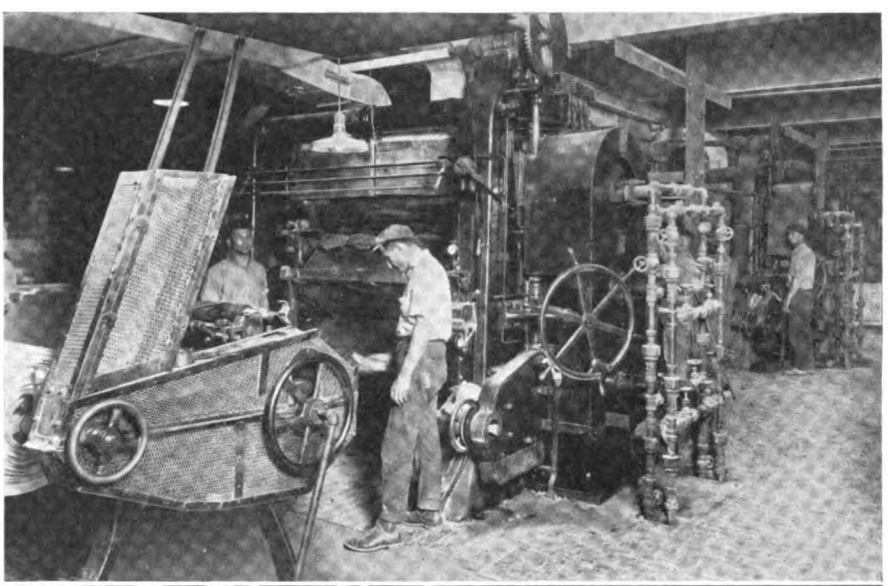
1. Waste per unit manufactured.
2. Percentage of "seconds" or rejections.
3. Direct labor per unit.
4. Departmental overhead.

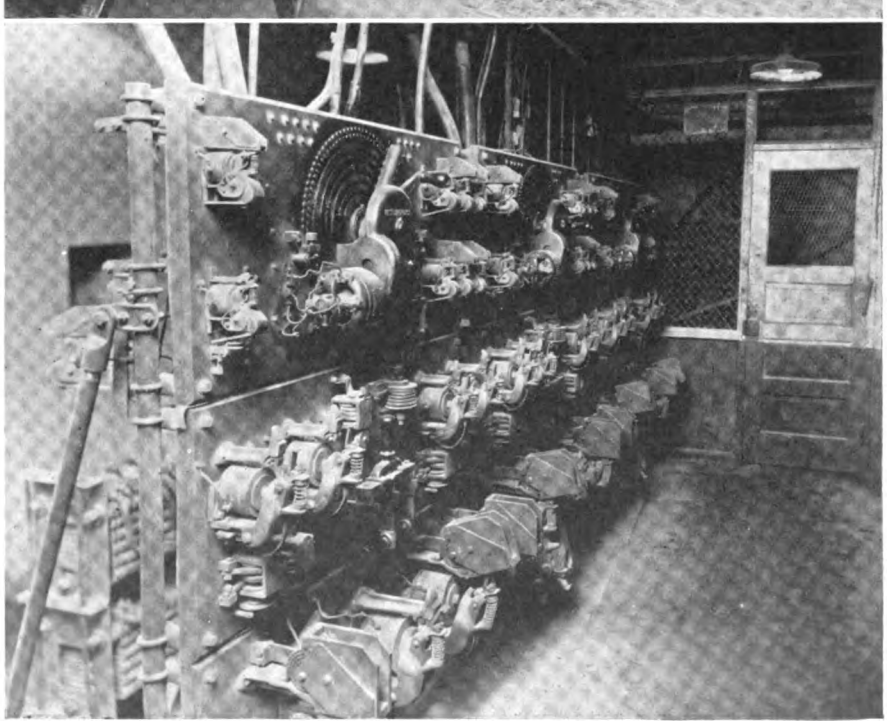
The percentage of importance of each varies somewhat in the different departments, according to the conditions. The waste or trimmings of each operator is collected and weighed each night. As a result the operators are more careful to cut fabric to the right length and use up short lengths of rubber stock.

The workers in the production departments do not have a bonus but work on straight piece work. The inspectors in the *Pneumatic Division*, however, who are wage earners, work on a monthly bonus similar to and with the same factors as the bonus for foremen in that division.

Where Emphasis Must Be Placed in a Maintenance Bonus

In a bonus of this kind on maintenance one point must be kept in mind and impressed thoroughly in





Figs. 9 and 10—Another view of the three calender mills (Fig. 1) and their control mechanism.

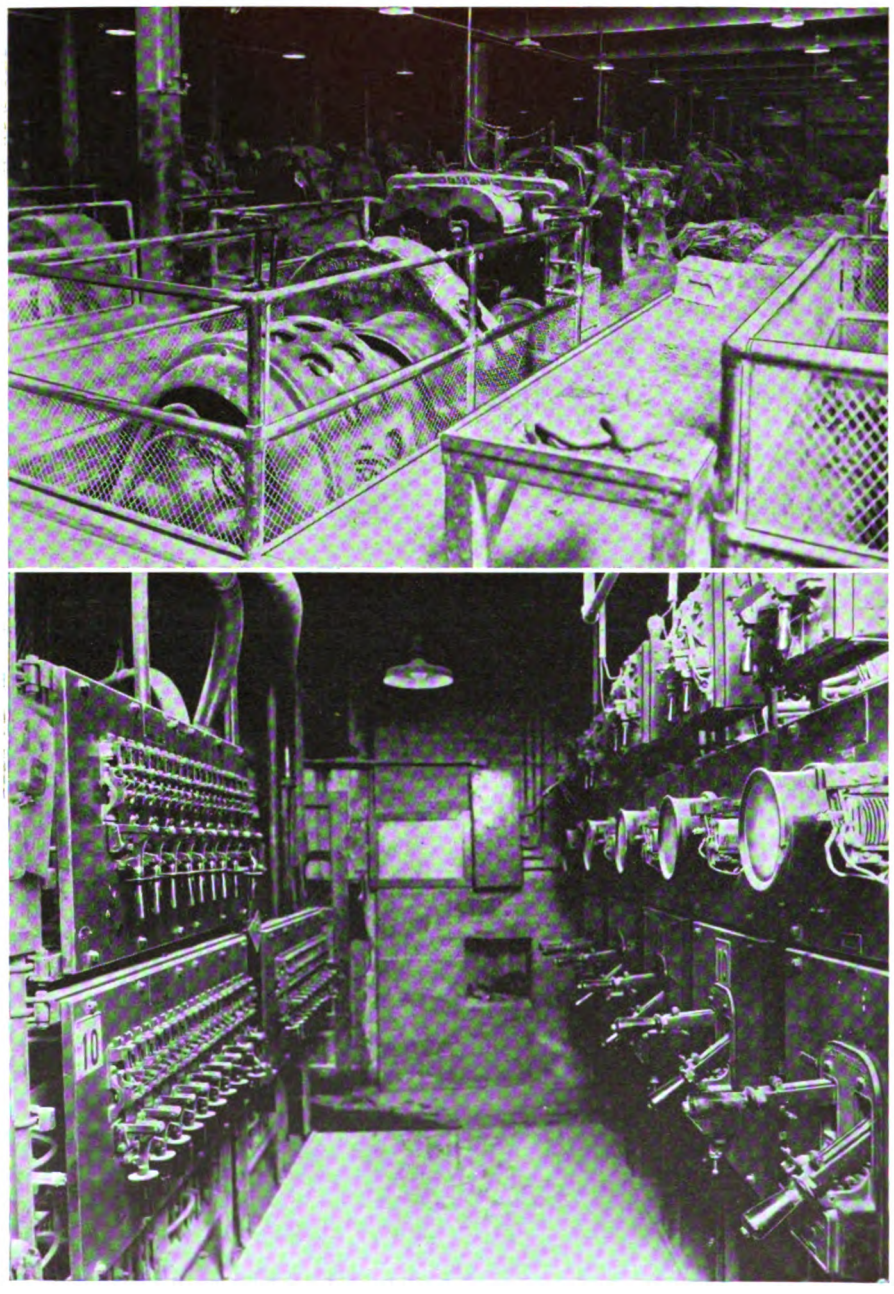
To be able to start up slowly and gradually build up to full speed the motor on each mill has adjustable speed control obtained through the motor-operated field rheostat accelerated by Type C Westinghouse control. As the operator at the desk (Fig. 1) pushes the "increase" or "decrease" button the small motor advances or moves back the rheostat contact arm as long as his finger is on the button. In this way the three machines are brought up to uniform speed when operating as one unit. Weekly inspections and immediate replacement of all worn parts reduce the shut-downs for repairs to a minimum.

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the minds of the different foremen; namely, that nothing is to be gained by skimping on maintenance costs. A big saving through skimping during one three-month bonus period may eliminate all possibility of a bonus for several periods afterward, because repairs put off or half done are then twice or sometimes three times as expensive as they should be. Any savings from doing a poor job are slight, especially when divided among all the jobs during a three months' period. Rather, it is better in the end, from both bonus and company standpoints, to do a little extra if it will decrease repair costs in the future. One example shows how this is working out. In one of the departments several different makes of motors are used although all are of the same horsepower. The result is that there is but little flexibility because the motors are not interchangeable on the different bases and often a motor must be "petted" along to keep it going until repairs can be made out of hours on overtime. Now, whenever it is necessary to take one of these motors down for repairs, the base is made standard at a slight additional expense above the necessary repairs so that the next time it gets out of order a substitute motor can be put in its place in a few minutes and the motor repaired in the shop at a minimum of expense.

For the same reason bearings are lengthened when they burn out too often, parts are re-designed and strengthened when they break too frequently, and many other changes are made toward reducing repair and maintenance costs in the future, even though they are slightly increased on any one job.

One place which requires weekly inspection is the adjustable speed motor control system (Fig. 10) for three calender mills (Figs. 1 and 9), which are used for impregnating the fabric with rubber. These three mills are placed in line and may be operated individually or in a group with the work passing in one continuous line through and operated on by all three machines. Each machine is driven by its individual 100-hp. motor. To get adjustable speed control, 440-volt direct current is used. These, by the way, are the only direct-current motors of any size used. A push-button control at each mill puts the motor under control of the operator when each calender is operated individually. The control mechanism (Fig. 10) is located in the basement, under the group of calenders. When the three mills are operated as a group the speed and operation for each of the three machines is controlled through a set of push-buttons by the man at the desk shown at the left in Fig. 1. He speeds up or decreases the speed of any of the three mills as necessary to keep them operating uniformly. Each of the three individual sets of push-buttons at his desk are marked: "Start," "Stop," "Reverse," "Slow," "Fast," "Increase," "Decrease" and "Inch." The minimum speed of these 100-hp. motors is 40 per cent of the maximum speed. The contact points in the control are burned by the frequent changes in speed and at the weekly inspection are scraped or renewed whenever they show any wear.



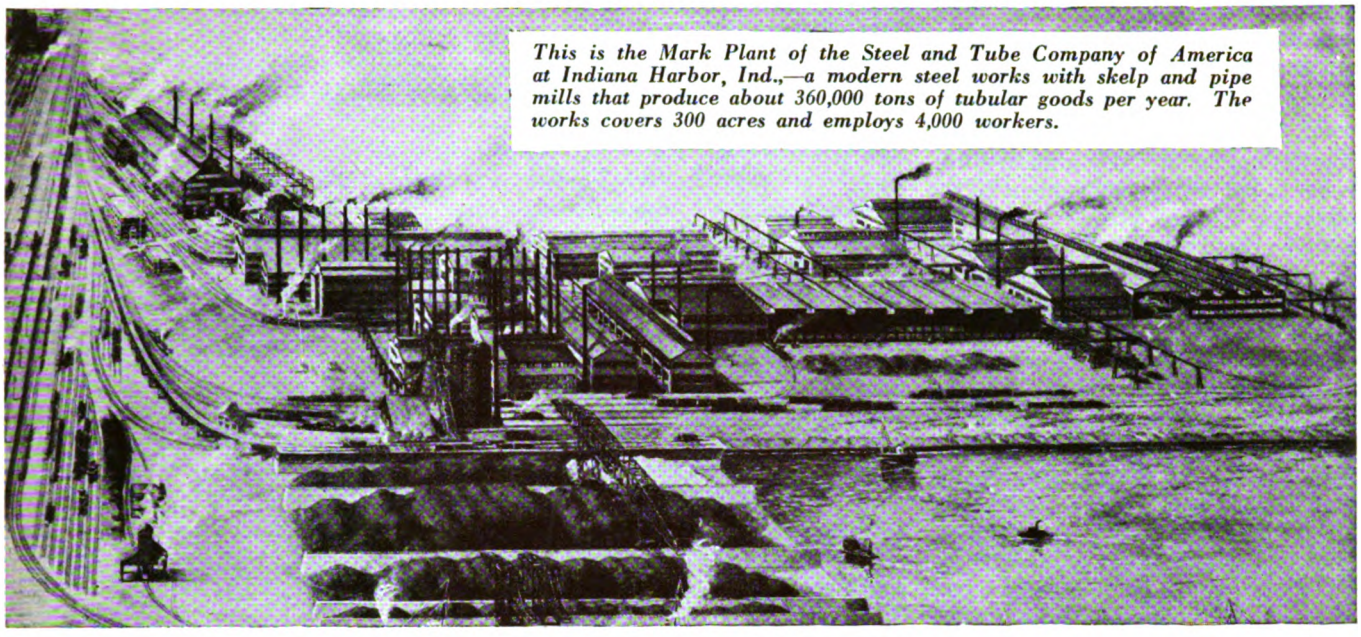
Figs. 11 and 12—One of the mill motor units and its control mechanism.

Groups of five or six rubber mills are driven from pinions on a long shaft which in turn is connected through a reduction gear to 400- or 500-hp., 2,300-volt, 60-cycle, 3-phase motors. The control mechanism is placed in the basement, as shown at the left. The equipment for the motor of each group of machines is numbered conspicuously. The door to this room is left unlocked so that anyone responsible can easily get into it in an emergency. The panels at the left carry Cutler-Hammer multiple switch starters. At the right, indicating ammeters are placed on the center panel with Westinghouse Type F oil breakers, manually operated, at the bottom and Cutler-Hammer overload circuit breakers at the top.

Equipment Records Kept

The record card, Fig. 3, is kept by the *Electrical Department* for each motor in the plant. On the back of this record is entered the number and location (*Continued on page* 67)

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This is the Mark Plant of the Steel and Tube Company of America at Indiana Harbor, Ind.,—a modern steel works with skelp and pipe mills that produce about 360,000 tons of tubular goods per year. The works covers 300 acres and employs 4,000 workers.

Some of the Ways

Procedure in Maintenance Work Can Be Audited

By the Maintenance Department to Improve Standards of Power Service

By ARTHUR J. WHITCOMB
Formerly Assistant to Superintendent, The Steel & Tube Company of America

AN AUDITING or accounting system is often looked upon as a necessary evil in the handling of a small business but as the departments of that business expand and competition becomes keen, the accounting system becomes more and more important and the auditor is looked to for information that will show the trend of operations from the standpoints of profits and losses.

Granting that these conditions hold true for all lines of business, why is it not logical to apply the accounting principle to operating and maintenance procedure in industrial works? Here as in any business certain expenditures are essential to the continuity of production and certain credits result from the maintenance of adequate operating service standards from the standpoint of continuity of operating processes. The factors that can be controlled are interruptions caused by preventable failures of machines from natural wear and tear, accidents and the like. Without definite information by which to measure or compare results of different service standards and balance expenditures against possible economies shown by continuity of operations or increases in quantity or quality of the product produced, the final audit of the business is no true indication of the degree of intelligence that is applied between the receipt and expenditure of the moneys that an audit will show.

THIS IS THE FIRST of four articles that will analyze the essential factors of maintenance procedure. It takes up a method of handling repair and replacement materials, to show the need, storing and use of same. Some of the points covered are: How the storekeeper keeps track of his stock; how he knows what and when to reorder; how requisitions are approved and materials drawn from stock; how invoices are passed for payment; how charges are made to departments using the materials. The second article will take up an accounting of power service; the third an accounting of the work of the electrical department; how charges are made to counting of electrical equipment used in production processes.

The purpose of this article and others that will follow it, is to show how an audit may be made of the operations of a maintenance department before and at the time the expenditures are being created by that department. This method will include: (1) A means of auditing the incoming and outgoing electrical material, such as repairs, spare parts, etc. (2) A power service audit; that is, a power distribution. (3) An accounting of the work of the men in the electrical department. (4) An accounting or record of electrical equipment.

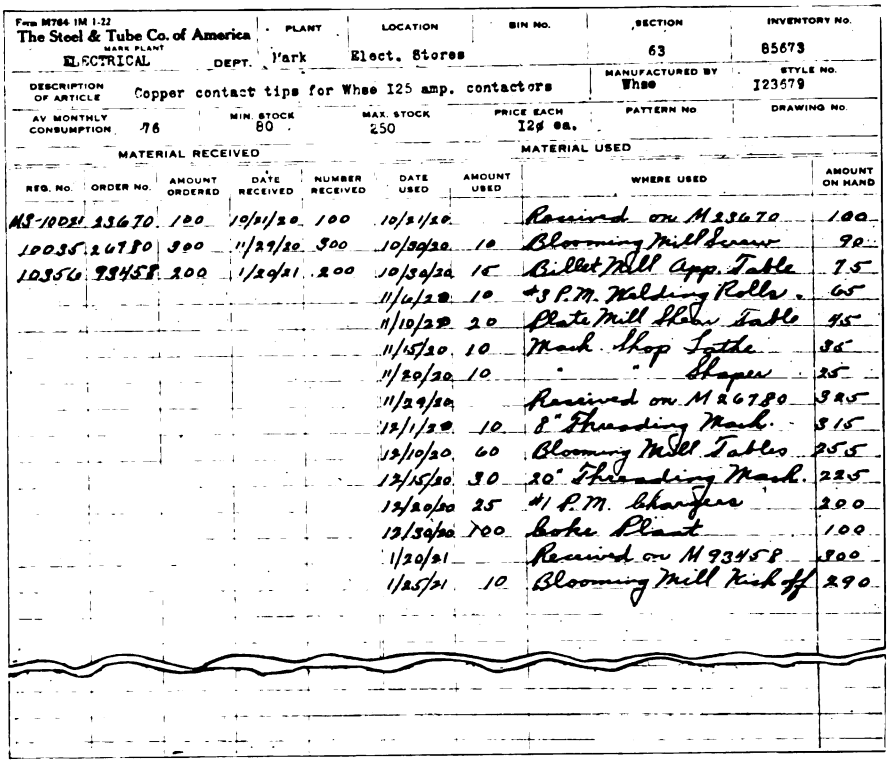
In this article a method of accounting for electrical material in the maintenance of power service in a large works will be discussed.

One of the first necessities of the auditor is a safe. The first necessity in accounting for material is a storeroom in which all maintenance materials may be stored. This storeroom should have a central location and should be adjacent to the electrical repair shop. The storeroom is controlled by a storekeeper who is charged with the receipt, storing and disbursement of material. He should have one or more assistants as needed.

In many plants electrical materials are kept in a main storeroom. Since electrical material is quite different from other material and consists of

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a great variety of raw material as well as a multiplicity of small parts, not commonly known to most people, it will be found that ordinary storeroom help will have difficulty in finding the material. Also a main storeroom is not always convenient to the electrical repair shop. For these reasons the writer believes it is best to have the electrical storeroom a part of the electrical department and under the supervision of the electrical superintendent. This fixes the responsibility on one person and the electrical superintendent is better qualified to keep on hand the materials he needs to run his department. He should set up a system for requisitioning material as needed and his storekeeper should issue charge tickets for all material disbursed. Under this plan the main storeroom receives the material as it enters the plant, keeps a record of the receipts and passes it directly to the electrical department. The charge tickets for material disbursed will then go to the main storeroom for pricing and auditing. This work can be readily done at the main storeroom by a clerical force and it reduces the clerical work required in the electrical department.



Form M764 IM 1-22
The Steel & Tube Co. of America — PLANT: Park — LOCATION: Elect. Stores — BIN NO. — SECTION: 63 — INVENTORY NO.: 85673
MARK PLANT: ELECTRICAL — DEPT.
DESCRIPTION OF ARTICLE: Copper contact tips for Whse 125 amp. contactors — MANUFACTURED BY: Whse — STYLE NO.: 123679
AV. MONTHLY CONSUMPTION: 76 — MIN. STOCK: 80 — MAX. STOCK: 250 — PRICE EACH: 12¢ ea. — PATTERN NO — DRAWING NO.

MATERIAL RECEIVED / MATERIAL USED

REQ. NO.	ORDER NO.	AMOUNT ORDERED	DATE RECEIVED	NUMBER RECEIVED	DATE USED	AMOUNT USED	WHERE USED	AMOUNT ON HAND
MS-10021	23670	100	10/21/20	100	10/21/20		Received on M23670	100
10035	26780	300	11/29/20	300	10/30/20	10	Blooming Mill Crane	90
10356	93458	200	1/20/21	200	10/30/20	15	Billet Mill App. Table	75
					11/6/20	10	#3 P.M. Welding Rolls	65
					11/10/20	20	Plate Mill Shear Table	45
					11/15/20	10	Mach. Shop Lathe	35
					11/20/20	10	" Shaper	25
					11/29/20		Received on M26780	325
					12/1/20	10	8" Threading Mach.	315
					12/10/20	60	Blooming Mill Tables	255
					12/15/20	30	20" Threading Mach.	225
					12/20/20	25	#1 P.M. Shapers	200
					12/30/20	100	Coke Plant	100
					1/20/21		Received on M93458	300
					1/25/21	10	Blooming Mill Kick off	290

Fig. 1—The backbone of every accounting system is the ledger. Similarly the backbone of the stores accounting system of an industrial works is a ledger arranged in the form of a card system. The cards are known as inventory cards and a convenient form is shown above.

A Good Arrangement for a Storeroom

In the electrical storeroom a great many small parts are stored, hence the best arrangement is rows of steel bins arranged back to back and in tiers up from the floor. The bins should be of various sizes and for some articles steel drawers are convenient. Coils can be stored on shelves and wire and cable may be neatly arranged on reels. The smaller sizes of wire may be left on the spools and the spools placed on the shelves.

All bins, drawers, or shelves should have a card holder. On the card a brief description of the material is essential together with the manufacturer's style number, such as "Whse. S, No. 123679 Contact Tips for 125 Amp. Contactor." The inventory number of the material should also appear on this particular card.

The inventory number or bin number, as it is sometimes called, is a number assigned to a certain kind of material. Each different kind of material should have a different inventory number. This number definitely identifies the material, for each different material has a different inventory number as shown below:

Inventory Number	Description
85673	Whse. S, No. 123679 Contact Tips for 125-amp. contactor.
85674	Whse. S, No. 123680 Contact Tips for 250-amp. contactor.
85675	Whse. S, No. 123694 Contact Tips for 500-amp. contactor.

The backbone of every accounting system is the ledger. Similarly, the backbone of the stores accounting system is a ledger arranged in the form of a card system. These cards are known as inventory cards. A suitable form is shown in Fig. 1. At the top of it spaces are provided for proper identification. The remainder of it is divided into two parts, one side for material received and the other side for material used. One side is a debit, the other is a credit. In other words, the card is simply a double entry ledger.

In the upper right hand corner of the card is a space for the inventory number on the bin in which the material is stored. This number definitely identifies the material. To the left of the inventory number is a space for the section number which will be explained later. The next space is not used because the bin number is the same as the inventory number. The next three spaces are for location, plant and department.

On the second line is a space for the description of the article. This should be complete, for it is from this description that the material is reordered. The description should tell what the article is and if it is a special part it should show what it is used for. If it is raw material such as red fibre, mica, etc., it should give the size or dimensions. The space marked "Manufactured by" is to show where the material may be obtained. There is a space for the manufacturers' style number, drawing number, and pattern number. These are essential to a complete description. There is also a space for the price per unit of quantity. This provides a record of previous prices of the material in buying a new lot. This value should not be used for charging out the material on hand as will be explained later.

There are spaces for "average monthly consumption," "minimum stock," and "maximum stock." These are required in order to tell when and how much to reorder. When the amount on hand gets down to the minimum stock, it is time to reorder. The usual plan is to order enough to bring the stock up to maximum amount. However, if the delivery is likely to be slow, it is best to add an amount determined by the average monthly consumption to take care of probable delays in delivery.

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On the "Material Received" side of the cards are columns for the requisition number, purchase number, amount ordered, date received and number received. On the "Material Used" side are the columns for the date used, amount used, where used, and amount on hand.

When material is ordered the number of the requisition and the amount ordered are placed on the "Material Received" side. When the material is received, the order number on which it was received, the date and the number received are placed in the remaining columns on this side. Also on the "Material Used" side an entry is made "Received on Order M....." and the amount received is added to the amount previously on hand. As disbursements are made, the date, amount, and place used should be written in on the "Material Used" side. The amount used is subtracted from the previous amount on hand, thus leaving the amount on hand after disbursements. Hence the last amount in the right-hand column represents the amount that should be in the bin of the storeroom.

When the amount on hand, as shown on the inventory card, gets down to the minimum stock, it is time to requisition more material. Fig. 2 shows a requisition form. The requisitions should be made out by the electrical storekeeper and numbered in the order they are issued. In the form shown, the requisition number is placed in the requisition number column of the inventory card, as well as in the upper right hand corner of the requisition form.

On the line above the approval space the use of the materials ordered is given. At the end of this line the account to which this material is to be charged is given. In this case it is to "Stores" as it will be charged out as used. On some construction jobs or special repair jobs the material is charged direct to the job. Therefore, a special account number should be assigned.

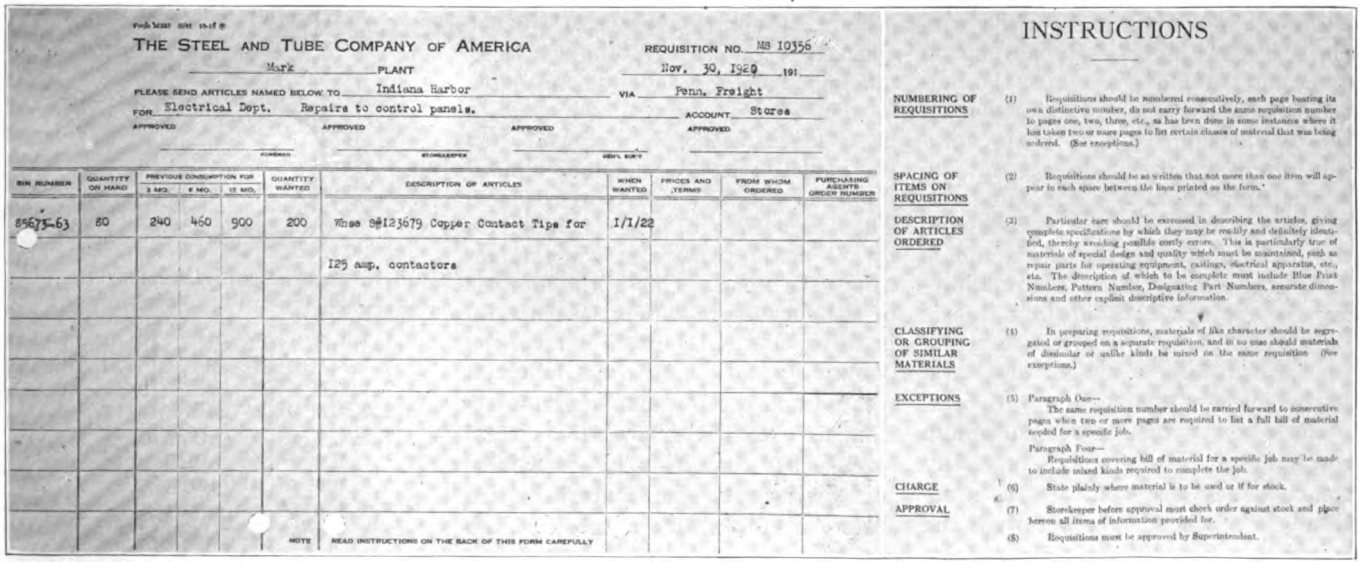
In the columns marked "Bin Number," the inventory number of the material is written, so as to provide positive identification of the material when it is received at the plant. In the next column the quantity on hand at the time of requisitioning is given. Next are given the consumptions for 3 months, 6 months, and 12 months. This can readily be found from the "Materials Used" side of card. These consumptions and the quantity on hand are given so as to show to the persons who must approve the requisitions that the materials are really needed. Also, it tends to keep the storekeeper from ordering too much or too little material at a time, for since he actually determines these figures he can see what past requirements were and can accurately judge the future needs.

In the column after the consumptions, the quantity wanted is given. Following that is the description of the article wanted. This should be complete as given on the inventory card and should include the manufacturers' style number, drawing number or pattern number, so that the manufacturer can readily determine the material desired.

The next column is for the delivery desired. This column is not intended for the words "At once." Material should be ordered sufficiently in advance to give the purchasing department time to get the best terms consistent with delivery and also to permit the requisition to go through the routine channels instead of being telephoned from one department to another and rushed out by special messenger.

The next three columns are intended for the use of the purchasing department. They may be filled in on the electrical superintendent's copy after the purchase order has been placed and a copy of the order received. In any event the purchasing agent's order number should be filled in, for this permits all the important information about an order for material to be kept on one sheet. The electrical department should always refer to its copy of the requisition when expediting the delivery of the material and in such cases it will be found convenient to have the purchase order number on it.

As mentioned before, the electrical storekeeper should make out the purchase requisition. In the works where the forms shown are used, four copies are usually needed and handled as follows: All four copies are sent to the electrical superintendent who signs his approval in the space marked "foreman." He then returns one copy to the electrical storekeeper for the electrical department records. The remaining three copies are sent to the main



THE STEEL AND TUBE COMPANY OF AMERICA

Mark _____ PLANT

REQUISITION NO. MS 10356

Nov. 30, 1919

PLEASE SEND ARTICLES NAMED BELOW TO Indiana Harbor VIA Penn. Freight

FOR Electrical Dept. Repairs to control panels. ACCOUNT Stores

APPROVED APPROVED APPROVED APPROVED

BIN NUMBER	QUANTITY ON HAND	PREVIOUS CONSUMPTION FOR 3 MO.	6 MO.	12 MO.	QUANTITY WANTED	DESCRIPTION OF ARTICLES	WHEN WANTED	PRICES AND TERMS	FROM WHOM ORDERED	PURCHASING AGENTS ORDER NUMBER
85673-63	80	240	460	900	200	Wmse S#123679 Copper Contact Tips for 125 amp. contactors	I/1/22			

NOTE READ INSTRUCTIONS ON THE BACK OF THIS FORM CAREFULLY

INSTRUCTIONS

NUMBERING OF REQUISITIONS (1) Requisitions should be numbered consecutively, each page bearing its own distinctive number, do not carry forward the same requisition number to pages one, two, three, etc., as has been done in some instances where it has taken two or more pages to list certain classes of material that was being ordered. (See exceptions.)

SPACING OF ITEMS ON REQUISITIONS (2) Requisitions should be so written that not more than one item will appear in each space between the lines printed on the form.

DESCRIPTION OF ARTICLES ORDERED (3) Particular care should be exercised in describing the articles, giving complete specifications by which they may be readily and definitely identified, thereby avoiding possible costly errors. This is particularly true of materials of special design and quality which must be maintained, such as repair parts for operating equipment, castings, electrical apparatus, etc., etc. The description of which to be complete must include Blue Print Numbers, Pattern Number, Designating Part Numbers, accurate dimensions and other explicit descriptive information.

CLASSIFYING OR GROUPING OF SIMILAR MATERIALS (4) In preparing requisitions, materials of like character should be segregated or grouped on a separate requisition, and in no case should materials of dissimilar or unlike kinds be mixed on the same requisition (See exceptions.)

EXCEPTIONS (5) Paragraph One—
The same requisition number should be carried forward to consecutive pages when two or more pages are required to list a full bill of material needed for a specific job.
Paragraph Four—
Requisitions covering bill of material for a specific job may be made to include mixed kinds required to complete the job.

CHARGE (6) State plainly where material is to be used or if for stock.

APPROVAL (7) Storekeeper before approval must check order against stock and place hereon all items of information provided for.
(8) Requisitions must be approved by Superintendent.

Fig. 2—When the amount of material on hand, as shown on the inventory card gets down to the minimum stock, it is time to requisition more material. This is a convenient form of requisition for this purpose.

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storeroom where approval is necessary to show that they have no such material in stock. They retain one copy for their records and for use in identifying the material when they receive it. The remaining two copies are sent to the general superintendent for his approval. When he has approved the requisition, one copy is sent to the plant expediter for his information in expediting the delivery of the material. The original is sent to the operating vice-president. After his approval, the requisition goes to the purchasing department.

When the purchasing department has placed the order for the material called for on the requisition, what is called a purchase order is issued. This is sent to the firm receiving the order, to the storekeeper, the accounting department, the expediter and the electrical department. On the purchase order is given all the information that is given on the requisition, together with name of firm with which the order was placed, the order number and the price.

When the material is received at the main storeroom, the receiving clerk identifies it from the order number marked on the package by the manufacturer. The receiving clerk then attaches a tag to the material. On this tag is written the description of the material and its inventory number.

Use of Memorandum of Receipts Form

The receiving clerk makes up the form "Memorandum of Receipts" in duplicate. On this form (Fig. 3) is marked the date of receipt, the freight item number, the freight charges, and the name of the carrier. Following this is the charge or account number to which the material is to be charged as shown on the requisition. Below this comes the purchase order number and the requisition number. The job number is only used for special construction accounts. In the next line is given the name of the firm supplying the material. Following this is the quantity of material received, the description of the material and its inventory number.

Both copies of the memorandum receipt are signed by the receiving clerk. They are sent to the electrical storekeeper together with the material. He acknowledges receipt of the material by signing his name to one copy of the form. This is returned to the main storeroom which in turn passes it to the accounting department as a voucher in passing the invoice for payment.

The electrical storekeeper places the material in the bin of the inventory number shown on the "Memorandum of Receipts." He also marks on the memorandum the amount of material he found in the bin at the time he added the new material. The inventory card is then taken from the file and on the material received side and on the same line as the requisition number on which the material was ordered, is placed the purchase order number, the date of receiving, and the amount received, as shown on the "Memorandum of Receipts." On the material used side of the card, the amount on hand is checked against the amount found in the bin at the time of adding the new material. The amount on hand is increased by the amount received by an entry "Received on Order M98343—200."

How the Storeroom Order Is Used

The last form of the series (Fig. 4) is the "Storeroom Order." This is used in charging out material. This form is made out by the foreman on the job that is using the material. He fills out all the spaces except the inventory number, price, total value and "charge." In the upper right hand corner of the form will be found three little spaces marked "Operation," "Construction" and "Special Repair." If the material is to be used for operation, the corresponding space is checked. If it is to be used for either of the others, their spaces are either checked or the account number written in. The date follows, and after it comes the department which is to be charged with the material. On the next line is the machine or place in which the material is to be used. The space for "Charge" is filled in by the main storeroom when it receives the form. This is the number of the account to which the material is to be charged. Then follows the quantity and kind of material wanted and the foreman's signature. This form is given to the electrical storekeeper and it is his authority for giving out the material. He enters the inventory number of the material on the form, and gets this number from the card attached to the bin from which he takes the material. He then finds the inventory card of this number and makes an entry on the material used side, of the date, amount of material used, and the place where used. The amount used is then subtracted from the previous amount on hand so as to give the actual amount now in the bin. When the amount on hand approaches the minimum stock, he issues a new requisition and the cycle of operation is repeated.

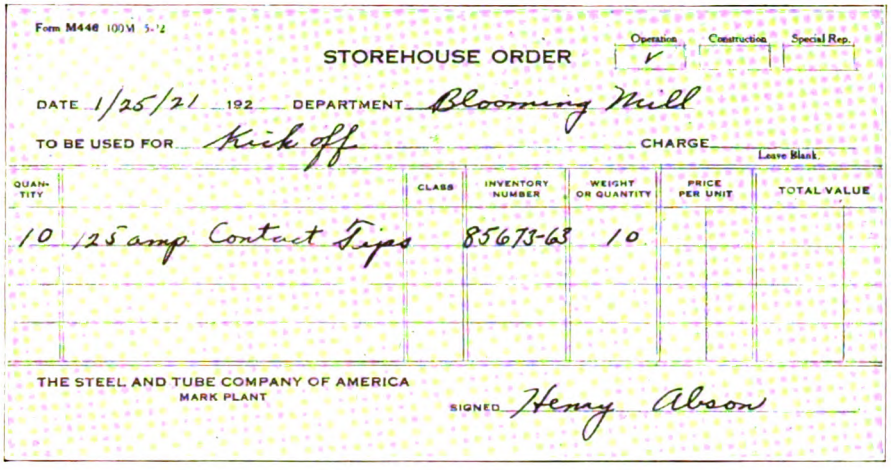
The "Storeroom Order" is then sent to the main storeroom where a set of cards is arranged in numerical order for inventory numbers. They find the card of the number called for on the "Storehouse Order," and price the material from their card and make the proper charge of the material. They are able to accurately price the material because when it was received they debited their card with the amount shown on the order for the incoming material. For each "Storeroom Order" received they credit or charge out the amount called for.

The inventory cards at the electrical storeroom are filed according to kind of material. There are several main divisions of the file, such as Armatures, Bearings, Coils, Contactors, etc. Each division is divided into subdivisions and the subdivisions are divided into sections. For instance, under the main division of coils are found the subdivisions of armature, field, stator and rotor coils as follows:

COILS (Division)
- Armature Coils (Subdivision)
  - Section 42—Type SK, Armature Coils
    - 10 HP 110 L SK.....Inv. No. 85675
    - 15 HP 120 SK.....Inv. No. 86546
    - 20 HP 110 L SK.....Inv. No. 86512
    - 20 HP 130 SK.....Inv. No. 86521
    - 35 HP 160 SK.....Inv. No. 86536
  - Section 43—Type MC, Armature Coils
    - 20 MC.....Inv. No. 86521
    - 30 MC.....Inv. No. 86528
    - 40 MC.....Inv. No. 86541
    - 70 MC.....Inv. No. 86565
    - 80 MC.....Inv. No. 86572
    - 90 MC.....Inv. No. 86548
- Field Coils (Subdivision)
  - Section 44—Type SK, for Shunt Fields
    - 10 HP 110 L SK.....Inv. No. 87852
    - 15 HP 120 SK.....Inv. No. 87868
    - 20 HP 130 SK.....Inv. No. 87894
    - 35 HP 160 SK.....Inv. No. 88901
  - Section 45—Compensating Field Type SK (Different sizes of motors follow)
  - Section 46—Commutating Field Type SK (Different sizes of motors follow)

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Fig. 4—This is the storeroom order used in charging out material. It is made out by the foreman on the job and given to the storekeeper as his authority for giving out material.



Form M446 100M 5-'22

STOREHOUSE ORDER

Operation ✓ Construction Special Rep.

DATE 1/25/21 192 DEPARTMENT Blooming Mill

TO BE USED FOR Kick off CHARGE Leave Blank

QUANTITY		CLASS	INVENTORY NUMBER	WEIGHT OR QUANTITY	PRICE PER UNIT	TOTAL VALUE
10	125 amp Contact Tips		85673-63	10		

THE STEEL AND TUBE COMPANY OF AMERICA
MARK PLANT

SIGNED Henry Abson

Section 47—Type MC, Shunt Field (Sizes of motors follow)
Section 48—Type MC, Series Field (Sizes of motors follow)
Section 49—Type MC, Series Coils for compound motors (Different sizes of motors follow)
Stator Coils (Subdivision)
Section 50—Type CS (Different sizes follow)
Section 51—Type CW (Different sizes follow)
Rotor Coils (Subdivision)
Section 52—Type CW (Different sizes follow)

It will be noticed that the sections are arranged in the file in numerical order. It is for this reason that the section number is always included as part of the inventory number. It follows the inventory number, separated by a dash, thus, 86573—63.

The most convenient way of filing the inventory cards is a vertical file. The main divisions are separated by red fibre separators with suitable index tabs, and the subdivisions may be separated by green fibre with suitable index tabs. The sections should be in the form of a folder, open at the top, and all of the inventory cards of that section placed therein. On the index tab of the folder should be placed the name of the section as well as the section number. Thus in looking for a certain card in the file, it may be found by looking for the class of material and then finding the right section and then the card in the section. If the section number is known, the proper section may be pulled out at once and the card found immediately.

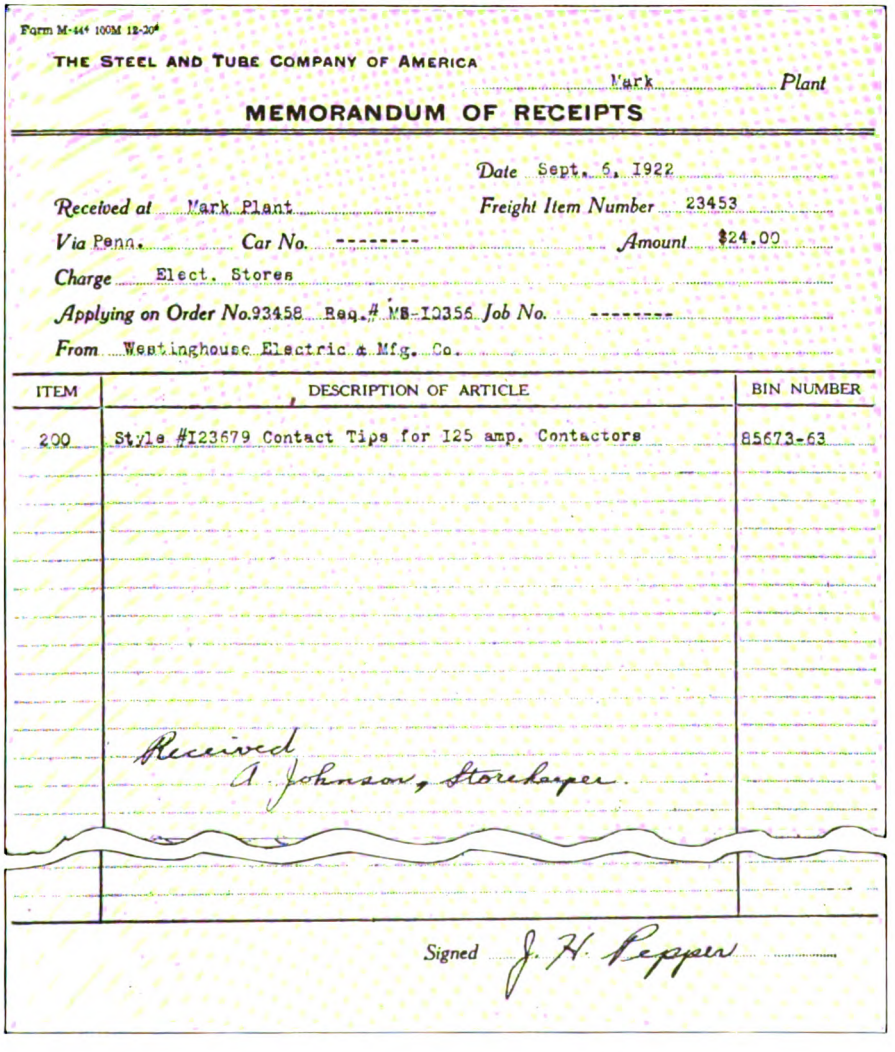
It will be found of value to keep two records of the assignment of inventory numbers to the different kinds of material. One list will be of inventory numbers in numerical order and will give the inventory number, the description of the material and the section to which the material was assigned, as follows:

Inventory Number	Description
85673—Whse. S, No. 123679, Contact Tips	Sec. 63
85674—Bearings Pattern No. 6425	Sec. 21
85675—Arm. Coils for 110 L, SK, 10 HP motor	Sec. 42

This record can be used in assigning new inventory numbers and also to find the section number to which a given inventory number belongs.

The other record is made up in numerical order of sections. Under each section is given all of the inventory numbers of the section and a description of the material for each inventory number. This record is made up as shown in the tabulation giving the arrangement of divisions, subdivisions and sections. This record is convenient in finding the inventory number of a given article, as it is quicker to look through this than through the card file. Both records can be made up in a loose-leaf form of note book.

This method of handling material keeps a strict account of the material and of itself renders an audit of the need, storing and use of material. (*Continued on page* 66)



Form M-446 100M 12-20

THE STEEL AND TUBE COMPANY OF AMERICA

Mark Plant

MEMORANDUM OF RECEIPTS

Date Sept. 6, 1922

Received at Mark Plant Freight Item Number 23453

Via Penn. Car No. -------- Amount $24.00

Charge Elect. Stores

Applying on Order No. 93458 Req.# MB-10356 Job No. --------

From Westinghouse Electric & Mfg. Co.

ITEM	DESCRIPTION OF ARTICLE	BIN NUMBER
200	Style #I23679 Contact Tips for I25 amp. Contactors	85673-63

Received
A. Johnson, Storekeeper.

Signed J. H. Pepper

Fig. 3—This form headed "Memorandum of Receipts" is made out by the receiving clerk who sends it in duplicate with the material to the storekeeper. One copy is receipted and sent to the accounting department as a voucher in passing the invoice for payment. The other copy is used in making entries on the inventory card.

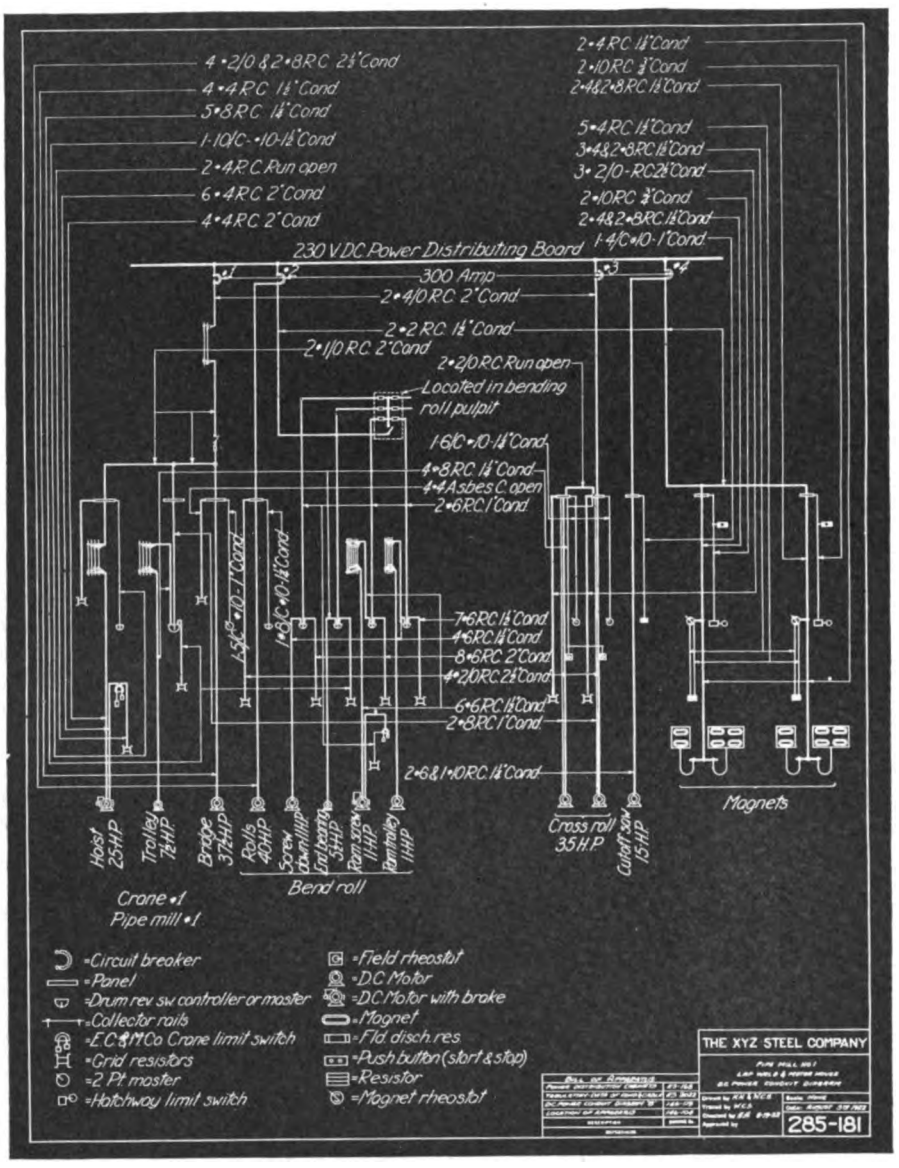
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IN NEARLY EVERY industrial works at one time or another, the services of a consulting engineer or a mill electrical contractor may be required. When the work to be done is let on a contract basis, the duties and responsibilities of a mill owner or his representative, the engineer and the electrical contractor should be carefully recognized. In this article these points are taken up together with construction data and records needed when figuring installation work.

Duties and Responsibilities of

The Engineer and Electrical Contractor

And Their Relations With the Customer on Contract Jobs in a Factory or Mill



Between this blueprint and the actual installation work which it calls for lie the specialized functions of the consulting engineer and the electrical contractor.

By DANIEL H. BRAYMER
Editorial Director, Industrial Engineer

IN THOSE cases where electric wiring and the installation of equipment in new extensions to industrial plants or changes in existing installations are not executed by the operating organization of the plant, this work is usually handled by contracts made with a consulting mill engineer and industrial or mill electrical contractors. Where this work is extensive it has been found advisable and most economical to retain an engineer charged with the responsibility to draw up specifications, make layouts, plans and cost analyses and sublet the installation work to an industrial electrical contractor who will execute it under the inspection and general supervision of the engineer.

With the growth in extent and character of electric service in mills and factories, two phases of mill engineering have grown in direct proportion. One involves the analysis of service conditions and the planning, specifying and laying out of the equipment required. This work falls to the engineer, working in close co-operation with the mill owner and his operating organization. The other involves the translation of these plans and specifications into details of construction and standards of workmanship. This work falls to the industrial electrical contractor, working in close co-operation with the engineer. The execution of the second phase of the work in connection with new mills and factories and the rehabilitation of old ones has opened a wide field of opportunity for the electrical contractor to establish standards of practice in keeping with engineering ideals of service that will bring to him a recognition for engineering and business ability in the field of electrical engineering of the same order that has been earned by the building contractor in other divisions of construction in the field of civil engineering. In electrical construction work there is a demand for not only good workmanship, but a knowledge on the part of the electrical contractor of electrical and mechanical operations in plant production and those changes and maintenance problems that come with plant expansion and natural wear and tear of the equipment involved. Moreover, there is also a demand for evidences of business judgment and integrity that will merit confidence in the handling of work that calls for the expenditure of thousands of dollars in materials and labor.

In the execution of industrial electrical construction work under the conditions that have been named, three parties are involved. First,

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the mill owner or customer; second, his engineer or his engineering representative, and, third, the electrical contractor. On every job each has distinct and separate duties and obligations, and since in this article we are dealing with the problems of electrical construction on conditions that might be considered ideal or those worth while to aspire to, it will be in order to list the range of duties and responsibilities of these three parties to a job.

In the case of the mill owner and customer they are:

1—The detailing of responsibility for important engineering work to an engineer of recognized standing. This is not only a matter of good judgment on the part of the mill owner or customer, that he may obtain the most efficient return on the investment of his capital, but it is a vitally necessary condition to obtaining fair competition on the actual work of construction when the contract for installation work is being let. For without the detailing of such responsibility to a qualified engineer the mill owner cannot always intelligently compare bids which may be submitted, nor can he be assured of receiving the full value for the money he is investing.

2—The appointment of one or more members of the plant operating organization to work with the engineer in the analysis and layout of the work to best meet production procedure, general maintenance and upkeep as carried out in the works.

3—The financing of the work.

In the case of the engineer they are:

1—To prepare definite and detailed plans and specifications, which may be the basis of bids by contractors and cover the work to be done as completely as possible, minimizing the amount to be performed as an extra to the contract.

2—To set standards of quality and kind of equipment to be used.

3—To set standards of quality and kind of workmanship to be required of the contractor.

4—To compare bids for work and judge responsibility and integrity of contractors submitting these bids. This includes advice to the customer on the details of the bids and his knowledge of and experience with contractors bidding as regards their technical and financial qualifications for handling the work.

5—To inspect installation work and require its strict conformity to specifications.

6—To adjust conflicts or interferences between the work of different contractors on the job, involving such items as location of apparatus, piping, wiring, etc., and fairly to place the responsibility for any additional expense that may be involved.

7—To authorize items of work extra to the contract not included in the original specifications when such work originates after drawing up specifications and securing bids, and to adjust changes in contract price resulting from changes in original specifications.

In the case of the electrical contractor they are:

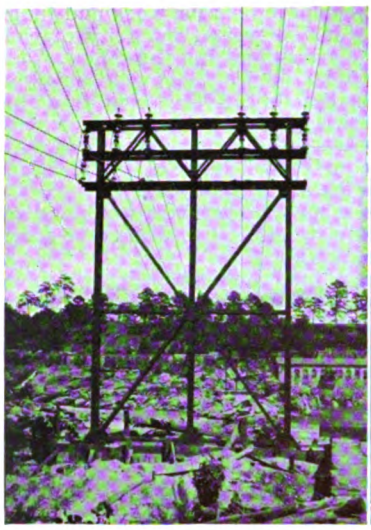
1—To execute all work in accordance

Table I.—Types and Sizes of Materials Required for Emergency Stock When Handling Electrical Construction in Mills and Factories

Angles—flat galvanized and black channel.
Boxes—galvanized and cast iron.
Boxes—outlet and switch.
Box Connectors.
Bolts—all sizes and lengths, galvanized.
Blocks, Test.
Bus Copper and miscellaneous switchboard fittings.
Bushings—Federal type.
Bushings—galvanized conduit.
Condulets and Covers—all popular types and sizes ½ to 4 in.
Conduit—ells and couplings.
Conduit—flexible metallic.
Clamps—Mathews 4-bolt cable.
Compound—cable bell.
Cleats—All sizes and voltages 1,000,000 c.m. and smaller.
Cross Arms—galvanized.
Cross Arms—braces galvanized.
Cutouts—complete line 600, 250, 125 volts.
Dosserts—all sizes type A and S for 750,000 c.m. to 0000 B. & S.
Fixture Studs.
Floor Rings—split, nickel plated.
Fixture Loops—Besco 16801.
Fuses—all sizes and voltages.
Fire Extinguishers—one qt. Pyrene.
Flexduct—all sizes ⅛ to 2 in.
Forks—561 Pierce galvanized.
Ground Clamps—⅜ to 4 in.
Guy Material—anchors, turnbuckles, insulators, thimbles and clamps.
Insulators—2200 volt pin type and wood strain.
Knobs—5½ Nailet.
Lugs—all sizes up to 1,000,000 c.m.
Lighting Brackets—street series.
Lightning Arresters—compression chamber 220, 550, 2200 volt.
Lag Screws, Galvanized—from ⅜ by 2 to ⅝ by 6 in.
Lead—sheet and ¼ in. pipe.
Lamp Cord—G and Y and reinforced 18 B. & S. and 14 B. & S.
Lock Nuts—conduit.
Moulding, Wood and Fittings.
Motors and Bases—as required.
Nuts—galvanized machine bolt.
Poles—30 and 35 ft.
Pipe Railings and Fittings.
Pole Steps—galvanized.
Pipe Straps—6 in. and smaller, galvanized.
Racks, Pierce—secondary 5, 3 and 2 spool.
Receptacles—all popular types.
Rosettes—all popular types.
Bases—all popular types.
Wood Screws—round head, blued 3½ No. 16 and smaller.
Screw Hooks—No. 1 and 1818 G, galvanized.
Switches—knife, 200-amp., 250-volt and smaller; 100-amp., 600-volt and smaller.
Switches—entrance.
Switches—safety miscellaneous.
Switches—push, snap, tumbler and door.
Switches—miscellaneous.
Switch Plates and Receptacle Plates—solid and stamped, BB and nickel.
Solder and Paste.
Sockets—P. B. key, keyless and pull chain.
Tools—for sale at cost to workmen.
Tape—rubber, friction, varnished cambric and weather proof.
Tubes—porcelain 2-in. by 30-in. and smaller.
Wire and Cable—Underwriter's white, 750,000 c.m. to 12 B. & S.
Wire and Cable—RC 0000 to No. 14.
Wire and Cable—VC 0000 to No. 12.
Wire and Cable—WP 750,000 c.m. to No. 10.
Wire and Cable—Miscellaneous—portable cord; flame proof; switchboard cable; colored braid, switchboard cable; 2200 volt triple conductor leaded cable; galvanized telephone wire.
Washers—galvanized ⅝ and smaller.
Transil Oil and P. B. Paint.
Reflectors—R. L. M. standard.
Pins and Oak Brackets and miscellaneous telephone line material.

Note: On January 1, 1923, the value of these materials on hand in the stockroom was about $25,000. Stocks about $1,000 in value included: Condulets, $2,461; Conduit, $1,456; Fuses, $924; Bolts, $911; Flexduct, $894; Sockets, $1,311; Tubes, porcelain, $1,317; Wire and Cable, $1,326.

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Some mill installations call for heavy and permanent construction for service connections to buildings. Here it was necessary to cross a river. The illustrations show the supports which were used for carrying twelve 750,000 c.m. cables from the substation to the mill.





with the spirit as well as the letter of the specifications.

2—To establish and maintain high standards of workmanship.

3—To plan the execution of work in such stages as will conform as fully as possible to the convenience and requirements of the customer and the schedules of other contractors executing other and associated parts of the installation work.

4—To provide such emergency stock as will prevent interruptions in the work under his contract through delays in shipments by manufacturers.

5—To make sure that the work is complete and conforms with specifications before calling upon engineers for final inspection.

6—To keep the clearest possible records of all extra work performed and to perform no extra work without the authorization of engineer or customer.

7—To establish such credit standing and standards of integrity as will guarantee the performance of a contract in all its engineering and legal details.

8—A responsibility of the good contractor, sometimes overlooked, is to place upon the work a foreman and a crew of men whose standards of integrity and conduct will at least conform to those of the community in which they are placed and in no way be an offense to the customer.

A contract form is an essential part of specifications for installation work which should be carefully prepared from the standpoint of completeness and clearness of installation requirements that will be considered by the engineer in his inspections and approvals of work done by the electrical contractor. Such a contract form as prepared by the engineer should cover the following points:

1—Duties and responsibilities of the electrical contractor.

2—Work covered by the specifications and quality of the materials that shall be used together with references to official rules and standards of insurance companies, state or municipal ordinances that must be met.

3—Separate outlines of the different parts of the work contemplated and schedules giving the order of handling it when the operation of existing machinery is to be considered.

4—Detailed drawings interpreting specifications and plans showing locations of apparatus, buildings and main circuits.

5—Inspection procedure and fees when municipal and state inspections are required.

6—Conditions under which work will be handled that represents additions, omissions or defects.

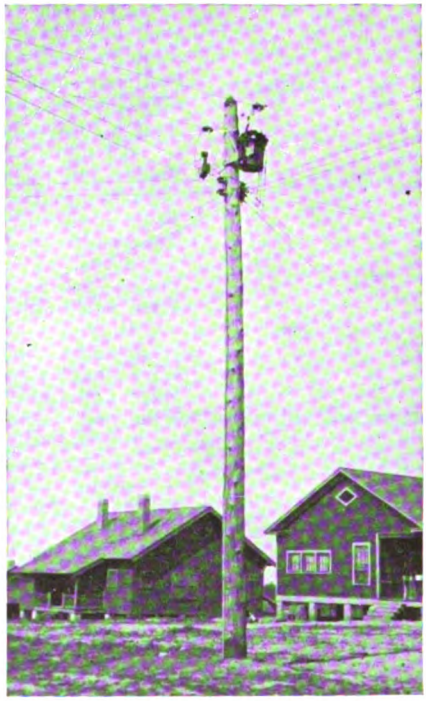
7—Conditions surrounding progress and completion of work.

8—Terms of payment for work done.

9—Requirements for final acceptance of work done.

10—Procedure covering conflicts in the work handled by different contractors.

11—Schedules of equipment to be purchased by the mill owner and the electrical contractor.



This is a typical construction for lighting of cotton mill villages surrounding the mill.

12—Explanations under separate headings in the specifications covering the general procedure to be followed in installing each element of the job and the character of workmanship expected. Such explanations should usually cover: Supports, joints and conductors for general wiring; provisions for and kind of exposed and inclosed wiring; requirements as to wiring devices and their locations, etc.; special clearances and special equipment that shall be used. These and like details are essential in addition to the usual detailed specifications covering layout and character of each specific installation or system shown in the layout drawings and detailed plans.

In most cases where a qualified engineer is retained by a mill owner the duties and responsibilities of each are simple and are well recognized. In other cases the duties and responsibilities of the electrical contractor are not so well recognized as they are inferred and legally made binding through the details of the contract as already outlined. In some cases the engineer undertakes a responsibility, often unfairly to himself, of compelling performance of work in accordance with the contract and frequently assumes that he can secure a kind of service in workmanship and ability gained only through experience that the electrical contractor does not possess and does not in any way reveal except through a low estimate in competitive bids. No criticism is intended for the engineer in this statement further than to say that he is in such instances assuming a responsibility in the execution of work on the sole basis of the lowest bid that is not fair to himself and his client and not conducive to the establishing of electrical construction work on such a business basis as will enable the electrical con-

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tractor to build a capable and experienced personnel; to assure the performance of the details of specifications in contract form; or the building of a reserve in business capital that will enable him to establish and maintain the emergency stock that is so essential to the completion of work without interruptions or delays.

A worse but less frequent modification of this practice is the submitting of the amounts of the total bids to the client for decision after selecting two or three of the bidders who are close together. The fallacy of this practice can be best illustrated by an example. Suppose a doctor is called for a patient who has measles. He shows the patient three medicines, all of which will be in varying degree effective but differ in cost by small amounts and then asks the patient to select one from which the dose will be prescribed. If a physician should follow such a practice his sanity would promptly be questioned by the medical profession.

In the case of electrical contractors, there is often found a deficiency in business methods and good judgment evidenced by a wildness of desire to secure a job without a definite and accurate knowledge of all its costs and the probable contingencies that are involved. On the other hand, some electrical contractors handling mill installations have spent much time in analyzing their work and devising detailed methods which show the necessary assurances and checks to be made in order that not only one but every job undertaken can be executed according to standards that will be easily recognized as complying with the most rigid of specifications, if they do not provide examples of improved practice gained through the experience of the capable men that they are thus enabled to employ.

Table II.—Main Items of Materials Needed on Three Different Kinds of Jobs

Materials Used	Job No. 1 Motor Installation only—91 Motors, 1408 hp.	Job No, 2 Lighting and motor installation—490 lights, 200 watts each and 431 motors, 1057 hp.	Job No .3 Lighting Installation only—716 lights, 150 watts each.
Wire	22,000 ft.	92,000 ft.	64,500 ft.
Conduit	6,000 ft.	26,100 ft.	18,300 ft.
Ells	350	400	95
Couplings	350	400	95
Flexible Metal Conduit	270 ft.	880 ft.	.....
Lock Nuts	1,700	2,360	2,950
Bushings	850	2,360	2,950
Flexible Box Connectors	180	600	.....
Split N. P. Floor Rings	30	204	120
Pipe Straps	1,200	4,550	3,700
Condulets	375	1,730	170
Fibre Conduit	.....	860	.....
Test Blocks	.....	117	.....
Cutouts	185	327	200
Fuses	185	1,010	850
Cutout and Junction Boxes	102	595	255
Asbestos Board	.....	265	.....
Gal .229 G. E. Compound for Potheads	15	32	.....
Pierce Racks	10	4	24
Gross of R. H. Wood Screws	16	32	70
Machine Bolts	85	85	80
Stove Bolts	600	630	700
Channel Iron	50 ft.	35 ft.	.....
Angle Iron (Galvanized)	24 ft.	.....	144 ft.
Ground Clamps	500	600	.....
Lugs for Cutout Boxes and Grounding	200	200	.....
Solder	100 lbs.	200 lbs.	125 lbs.
Paste	5 lbs.	20 lbs.	13 lbs.
Tape, Friction and Varnished Cambric	50 lbs. each	400	160
Total	$5,212	$15,100	$7,630
Miscellaneous	3,600	700	150

Job No. 1.—Miscellaneous items include: Motor supports, switch supports, gasoline, paint, hardware, bus bars and insulators, grounding material, iron for substation and transformer foundations—$3,600.

Job No. 2.—Additional items included: Outlet boxes, distribution panels (6); magnetic switches (4); reflectors RLM (490); and safety switches (51); circuit breakers (2). [Miscellaneous: Gasoline, paint, hardware, cutout supports, concrete and brick manholes; 1,000 ft. lead pipe for anchoring boxes and straps, bushed elbows, special castings, and junction boxes—$700.]

Job No. 3.—Additional items included: Outlet boxes (1,050); reflectors RLM (715); swivel RLM hangers (716); safety switches (175). [Miscellaneous: Gasoline, paint, hardware and supports for safety switches—$150.]

Character of Work That Is Covered by Table II

Job No. 1.—A straight motor installation of 91 motors, 1408 hp. The motors were operated on a 3-phase, 550-volt distribution system. The wiring was an all conduit job, overhead attached to wood beams.

Oil circuit breakers and compensators were used with motors and a few magnetic switches with push buttons.

The customer furnished the motors and switches and transformers.

The contractor furnished the substation structure and a long underground cut-in (100 ft.), using parkway cable installed in the ground without conduit. The work was done in a textile mill of slow burning mill construction.

The total cost was as follows:

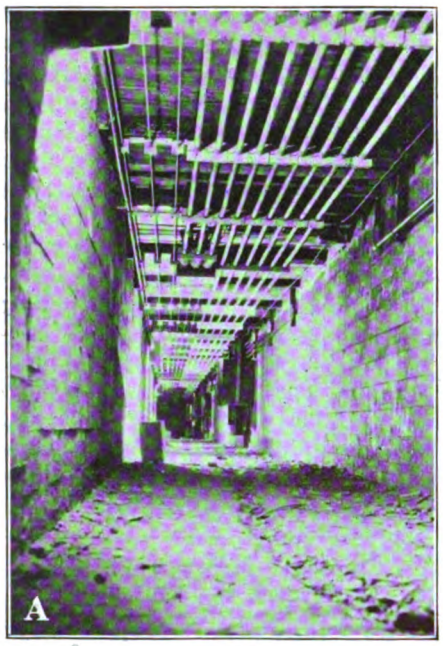
Material (substation equipment of $1,146 but no transformers or electrolytic arresters. Labor of $310)	$ 8,812
Labor	2,426
20% Commission	2,538
	$13,776
Substation	1,456
	$15,232

Job No. 2.—A mixed lighting and motor installation of 490 lamps, 220 watts each, and 431 motors totaling 1,057 hp. The work was done in scattered concrete buildings with all wiring exposed in conduit. The main switchboard was about 150 ft. from the service substation and it was practically 400 ft. from stepdown transformers to center of distribution. Between transformers and switchboard lead-covered cable was used in fiber conduit. The feeders from switchboard to center of distribution and to load were installed in conduit.

The motor job included 336 ½-hp. individual loom motors at 220-volt, 3-phase, with snap switch control; 47, 7½-hp. spinning frame individual motors with oil circuit breaker control but no compensators. There were 50 group motor drives and 5, 30-hp. motors using compensators or oil circuit breaker control. The motors other than those on looms were 550-volt, 3-phase and the lighting service was at 220-110 volts, single-phase, 3-wire from a 550-volt, 3-phase supply.

The lighting installation was in conduit and included 200-watt RLM units with small group control.

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Examples of Good

Electrical Installations

In a Cotton Mill

A—Construction in a feeder tunnel showing 500,000 c.m. feeders attached to the concrete ceiling.

B—Motor mounting on concrete ceiling without motor supports for 4-frame spinning drives. Fuse box and switch are also shown attached to ceiling with short conduit runs.

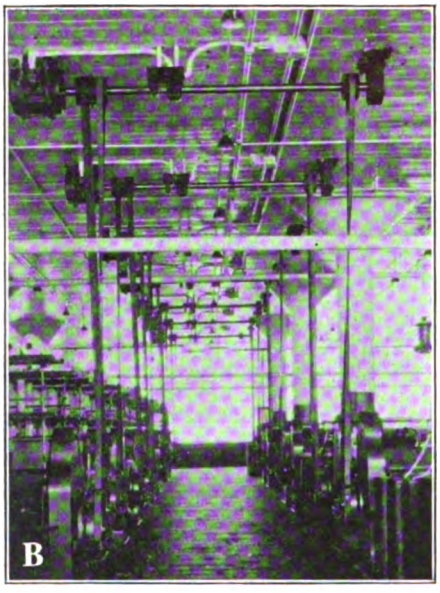
C—Insulated turnbuckles with 3-in. fibre conduit sleeves instead of tape protecting live parts. The cleats below permit lowering of sleeves for adjusting turnbuckles.

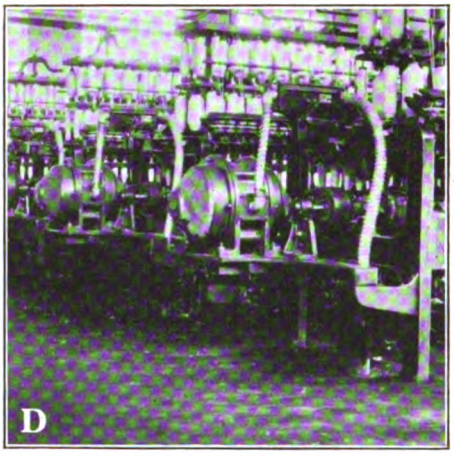
D—Individual motor and switch mountings on spinning frames.

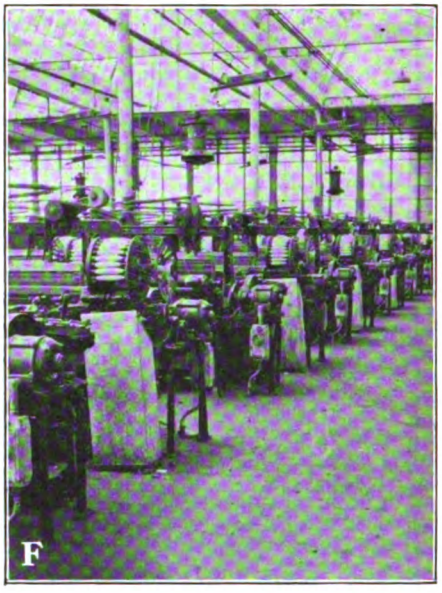
E—Messenger wire supports for mounting feeders to Cooper-Hewitt lights.

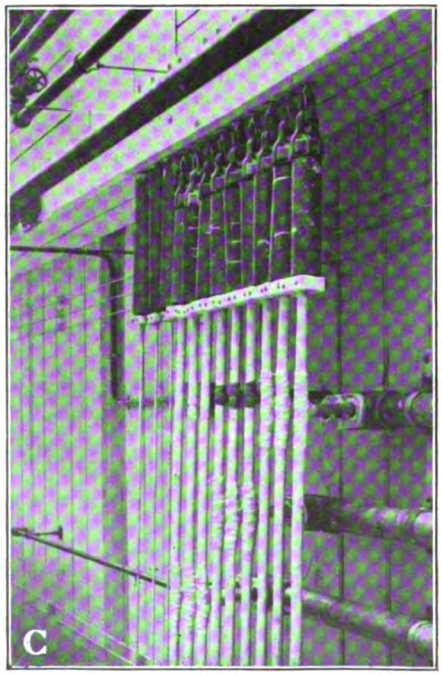
F—Another type of motor and switch mounting for looms.

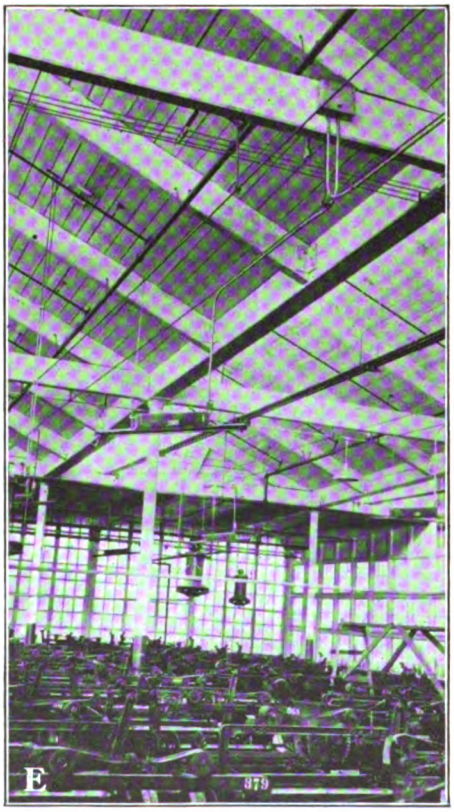
G—Strain supports for heavy feeders where they enter the building.

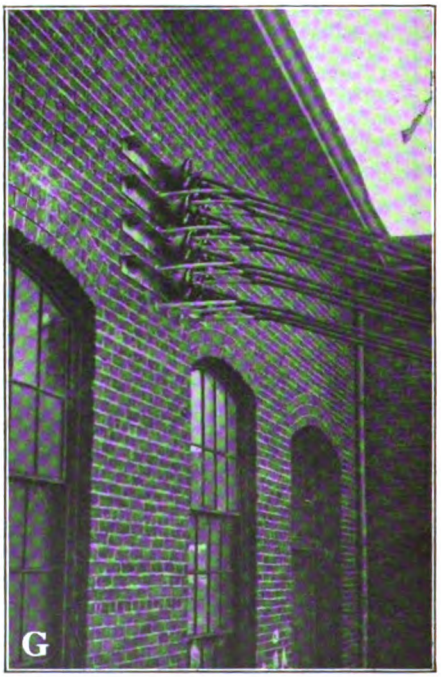












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The customer furnished the motors, control devices, switchboard and transformers. The contractor furnished all of the motor supports, distribution panels and wiring materials.

The total cost was as follows:

Material	$15,800
Labor	5,510
15% Commission	3,196
	$24,506

Job No. 3.—An all lighting job of 716 lights, 150 watts each. This was a change-over job in an old mill of slow burning mill construction in very scattered buildings. The entire distribution was at 220-110 volts, 3-wire from a 220-volt source of supply. RLM 150-watt units were used.

All wiring was in conduit on wood beams. The beams were bored for ½ and ¾ in. tubes and spanned for larger sizes. The feeders tapered as the load reduced. All feeders and switches were installed for the ultimate job but only one-half the total number of lights was installed. On remaining sections temporary connections were made to existing feeders.

The total cost was as follows:

Material	$ 7,780
Labor	3,068
15% Commission	2,077
	$12,925

Table III.—Convenient Form for Summary Sheet Used in Making Up Estimates on Installation Work

ESTIMATE NO. 1 DATE January 1, 1923

CUSTOMER John Jones ADDRESS Jonesville, N. C.

WORK Cotton mill electrical installation

ENGINEER John Doe SPECIFICATIONS NO. 100 DATE Dec. 20, 1922.

I - MATERIAL:

1 - Underwriter's Wire	$ 11.90		
2 - ____Percent on same	$ -----		
3 - Weatherproof Wire	$ 9.95		
4 - ____Per cent on same	$ -----		
5 - Varnish Cambric Wire	$ 5394.25		
6 - Rubber Covered Wire	$ 460.31		
7 - Wiring Devices and Supplies	$ 9858.72		
8 - Extra Freight & Express	$ 100.00		
9 - Truck	$ ------		
		TOTAL	$15,835.13

II - LABOR AND LABOR EXPENSES:

1 - Labor	$ 4350.00		
2 - Foremanship & Expenses	$ 600.00	- 20 weeks at $30	
3 - Expenses of ( ) Men	$ ------		
4 - Time and Exp. of Men in Travel.	$ 150.00		
5 - Build Stock Room	$ 50.00		
6 - Handle Stock	$ 50.00		
7 - Miscellaneous Errands	$ 25.00		
8 - Scaffolding	$ 50.00		
9 - Liability Insurance	$ 100.00	TOTAL	$ 5,375.00

III - MISCELLANEOUS EXPENSES:

1 - Office Expenses	$ -----		
2 - Travel. Exp. of Inspection	$ 75.00		
3 - License	$ 50.00		
4 - Tools	$ 50.00		
5 - Bond			
6 - Inspection Fee		TOTAL	$ 175.00

Total of all above	$21,385.13
IV - COMMISSION ON MATERIAL, LABOR & LABOR EXPENSES, AND MISCELLANEOUS AT 10% OVERHEAD	2,138.51
V - ITEMS WITH SPECIAL COMMISSION: ____ $ ____ TOTAL	$
VI - ITEMS WITHOUT COMMISSION: ____ $ ____ TOTAL	$
VII - CONTINGENCIES TOTAL	$ 1,000.00
GRAND TOTAL	$24,523.64
PRICE OFFERED	$24,525.00

Job was let for less than $21,000 to another electrical contractor.

I—Material:
Item
1—All conduit job—wire used for grounding.
2—Used when item is large because manufacturers will not guarantee weights within 3 per cent. This 3 per cent is added.
4—Same.
5—Used on power wiring throughout and large lighting feeders.
6—Small lighting feeders and mains and branches.
7—All wiring material and miscellaneous material.
8—Buying done on quotations f.o.b. job. Jobbers and manufacturers usually ship collect. This item also covers shipping tools and tool boxes to the job.
9—For job within radius of company truck from headquarters. Ordinarily customer trucks materials.

II—Labor:
Item
2—Pay foreman's living expenses up to $10 per week in addition to wages. He is expected to use about one-half his time in productive labor. On small job 100 per cent time in productive labor is expected.
3—Bonus to cover high living expenses during war. No living expenses allowed at present.
5—Men must have working space; space is sometimes furnished by mill.
6—Unpacking and sorting on shelves made from boxes used in shipping.
8—Building solid bucks and special heavy scaffolding with lumber furnished by mill. Normal breakage in step-ladders and straight ladders.
9—Liability to men and public based on pay roll. Runs up to 10½ per cent on some classes of work.

III—Miscellaneous Expenses:
Item
3—When out of state to cover state license.
4—Concrete mill construction wears out drills. No charge made for wear and tear but only drills actually consumed.
5—Municipal job only.
6—In cities only and covers city inspection.

V—Items With Special Commission: May be called upon to furnish motors and large transformers purchased by contractor.

VI—Items Without Commission: When agreement is made to draw plans and do layout, no commission is charged but billed as special work.

VII—Contingencies: Unusual work or conditions with undue hazards. In this case it was state contract with unusual conditions.

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Table IV.—An Analysis of Seven Motor Installation Jobs Showing Cost Per Horsepower. No Commission Is Included.

Job No.	RATING AND NUMBER OF MOTORS					TYPE OF JOB	INSTALLATION COSTS				
	Volts	Hp.	50 Hp. and over	10 Hp. to 50 Hp.	0 to 10 Hp.	Open or Conduit	Total	Material	Labor	Cost per Hp.	Types of Motor Drives
1	550	900	0	5	128	Mixed	$3925.00	$1981.00	$1596.00	$ 4.35	Individual
2	550	583	0	12	56	Conduit	3575.00	2329.00	886.00	6.15	½ Ind. and ½ group.
3	550	155	0	3	17	Conduit	1993.00	1163.00	560.00	12.80	½ Ind. and ½ group.
4	550	730	1	9	75	Conduit	3219.00	1902.00	887.00	4.40	½ Ind. and ½ group.
5	550	147	0	7	3	Conduit	1442.00	914.00	330.00	9.80	All group.
6	550	2765	24	68	3	Cleat	11700.00	7459.00	2976.00	4.20	All group.
7	550	550	0	7	70	Mixed	5400.00	3734.00	1122.00	9.85	⅔ Ind. and ⅓ group.

REMARKS:

Job No. 1—Unusually good feeder condition in that motors were closely grouped around center of distribution which was about the same as the switchboard location.

Job No. 2—A representative installation.

Job No. 3—Very exceptional feeder condition with long loops of 300,000 c. m. cable for connecting two generating stations.

Job No. 6—All group drive consisting of 75 and 50 hp. motors, except spinning frames which were all 4-frame drives.

Job No. 7—Included receptacle circuit throughout mill for portable extension lights and electric drills.—Unusually costly design of motor support was used and long underground cut-in.

The variation in cost per hp. is nearly in inverse proportion to size of job in hp. On certain jobs the contractor furnished motor supports for ceiling mounting and the customer furnished brackets on machines.

In the accompanying tables are set forth some of these methods and the data and information that is essential to an installation cost analysis of mill construction work in the installing of electric service. Table I shows the items that are considered essential by one large contracting company in their reserve or emergency stock to insure against delays in shipments or incomplete shipments of materials by manufacturers. Such a reserve stock cannot be built from the odds and ends left over from various jobs but must be an orderly stock complete in essential sizes and types. However, to such a stock certain quantities of leftover materials such as wire and cable can be added. But in a carefully made up bill of material for every job, such odds and ends should be negligible in quantity. Table II is made up from estimating sheets on three different types of jobs indicating the main items of materials required that are listed more briefly in a schedule form shown in Table III. Under the head of materials, this estimating schedule serves as a final check on the work to be done and presents the requirements of the job in such form that it is complete and easy for filing and for reference when estimates on other jobs are being prepared.

Table IV represents an analysis of motor installation costs that is useful in the same connection. It shows the trend of costs during the period the work is being done by the type and extent of the installation, the kinds of materials required and the amount of labor involved. Table V shows a similar analysis for lighting installations. These data do not lend themselves to definite conclusions or comparisons of costs and should not be so used, for the particular (*Continued on page* 66)

Table V—An Analysis of Nine Lighting Installations Showing Cost Per Square Ft. Lighted and Per Unit Used. No Commission Is Included.

No. of Job	Floor Area Lighted	No. of Lamps	Watts	No. Lamps	Watts	Total No. Lamps	Total Watts	Watts per Sq.Ft.	WIRING		INSTALLATION COSTS				
									3-Wire or 2-Wire	Open, Moulding, or Conduit	Total Cost	Cost per Sq. Ft.	Cost per Light Unit	Total Cost Material	Total Cost Labor
1	78,500	286	200	....	....	286	57,200	0.73	2	Conduit	$4253	$0.054	$14.90	$2718	$ 862
2	109,500	408	200	17	75	425	82,875	0.755	3	Conduit	3865	0.0352	9.10	2394	955
3	62,000	245	200	9	75	254	49,675	0.800	3	Cleat Mains and Cond. Brchs.	2458	0.0396	9.70	1478	659
4	33,250	185	150	....	....	185	27,800	0.84	3	Conduit	1825	0.055	9.90	1087	467
5	126,800	359	200	37	75	396	74,575	0.6	3	Cleat	5832	0.046	14.75	2950	2080
6	18,600	114	200	....	....	114	22,800	1.23	3	Cleat feeders Cond. M. & B.	1350	0.069	11.80	899	278
7	23,100	84	200	....	....	84	16,800	0.72	3	Conduit	770	0.033	9.10	399	265
8	110,000	381	200	36	75	417	78,900	0.71	3	Cleat	5280	0.048	12.60	2741	1375
9	34,400	122	200	2	75	124	24,550	0.72	3	Conduit	1296	0.038	10.45	674	453
Average	66,239					254	48,352				$2992	0.0348	11.37	1704.44	821.55

REMARKS: The factors entering into the "Cost Per Light Unit" are: (1) Quality and color of goods made. (2) Ceiling height and size of reflector required. (3) Conduit or cleat wiring. (4) Number of floors in building—risers and distribution therefrom. (5) Voltage of supply circuit—and consequent size of feeder to distribution transformers from source of supply.

Job No. 1—A 2-wire distribution system with source of supply 400 feet from center of distribution. Double throw switching was required.

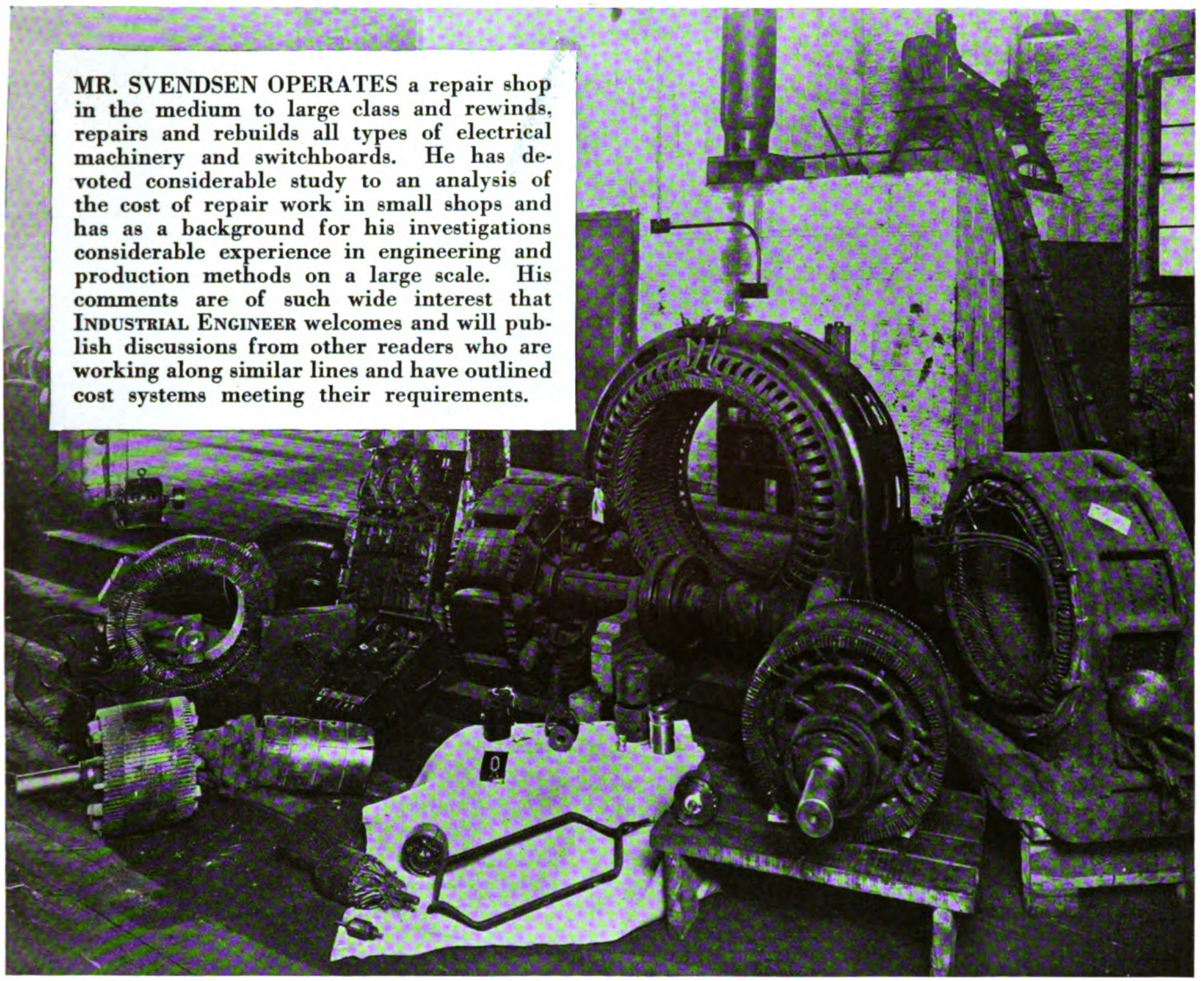
Job No. 2—Reflectors were furnished by the customer.

Job No. 3—Source of supply was center of distribution.

Job No. 5—Only part of transformers furnished but switches and risers for double the lighting installed.

Job No 8—Provided feeders for double the lighting service installed.

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MR. SVENDSEN OPERATES a repair shop in the medium to large class and rewinds, repairs and rebuilds all types of electrical machinery and switchboards. He has devoted considerable study to an analysis of the cost of repair work in small shops and has as a background for his investigations considerable experience in engineering and production methods on a large scale. His comments are of such wide interest that INDUSTRIAL ENGINEER welcomes and will publish discussions from other readers who are working along similar lines and have outlined cost systems meeting their requirements.

This photograph shows the wide range of jobs that come to a repair shop. Between the tiny armature in the foreground and the large stator in the background lie the elements that call for time, materials and experience and obey no set rules.

Some Problems Faced When

Analyzing Electrical Repair Shop Costs

That Make a Schedule of Prices Little More Than a Rule of Thumb Guide

By GEORGE P. SVENDSEN,
President, Boustead Electric & Mfg. Co., Minneapolis, Minn.

THE average commercial repair shop that is doing a wide variety of work at a fair profit has reached that point largely through main strength, awkwardness and considerable experience. When the labor and material costs for one particular class of work have been fairly well analyzed along comes the special job, that takes more time and special treatment and the refinement of a former analysis of costs again must be modified by good judgment and some luck in having available a coil winder who possesses a little initiative along with considerable skill.

Every man who is operating a repair shop has his own methods of getting at the proper billing price for a job, which is built up on a time and material basis with additions for the elusive term "overhead" that are good, bad and indifferent. There are several schemes for distributing overhead expense on different jobs that represent modifications between a flat percentage on the cost of labor and material to the complicated machine-rate and man-rate method. Most shops simply set a flat rate varying from 40 to 60 per cent of the cost of labor and material or they use a flat rate for covering the labor of all kinds that is required.

On the face of it, it hardly seems logical to charge the same rate for a man working outside the shop with a few hand tools as for the man using a high-priced machine requiring floor space, power, light, etc. Then to complicate matters, there is the problem of high-priced experts

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Here again is an illustration of how a profit is made or absorbed on a job in direct proportion to the number of benches and the presence or lack of nimble hands and wide experience.



who are put to work on jobs that a cheaper man could do, simply because they must be regularly on the pay roll to be available at all times for the particular kind of work at which they are skilled.

Here is another of our repair shop problems that the ordinary cost man doesn't get, and that is the great variety of our jobs. For example, our system of cost records must be able to take care of a big machine requiring all classes of labor and material, including engineering service, and still not be too cumbersome to take care of a little half-hour fan repair job requiring practically no material.

I am now working on a plan of classifying labor according to equipment and type of man normally required and making up a schedule of hourly rates accordingly. This will involve a new time card arranged for machine record, and is quite a problem to work out and still keep the bookkeeping within reasonable limits.

When this matter of analyzing costs is taken up in a detailed fashion, it is usually found that the subject is taken up from an accountant's viewpoint and the conditions found in a large factory geared up for quantity production, with little consideration given to the problems and operating conditions found in the small jobbing or repair shop.

About the first thing any cost expert recommends is a locked stock room with material issued on requisition only. This is fine for the ordinary factory but hits a snag in our work because so many jobs require only minute quantities of material whose individual cost is less than the cost to handle the requisitions. This almost broke up our stock room proposition until we issued this miscellaneous material on a budget basis, a scheme suggested by the Alexander Hamilton Institute during a correspondence on this subject. Such items as string, glue, insulating varnish, tape, solder, paste, etc., are issued to the shop in standard quantities once or twice a month and the foreman makes an estimate of the "budget" material on each job and marks it on his report. Whenever a job takes an appreciable

Schedule for Estimating Rewinding Charges for Induction Motor Stators

That use 2 and 3-phase windings operating on 110, 220, 440 or 550-volt circuits

Horsepower	*1,800 Revolutions per Minute*	*1,200 Revolutions per Minute*	*900 Revolutions per Minute*
½	$ 22.00	$ 24.00	$ 32.00
¾	26.00	28.00	35.00
1	28.00	32.00	40.00
1½	32.00	35.00	42.00
2	35.00	40.00	44.00
3	40.00	46.00	55.00
5	46.00	53.00	64.00
7½	55.00	64.00	74.00
10	64.00	74.00	80.00
15	74.00	81.00	100.00
20	81.00	94.00	118.00
25	86.00	112.00	125.00
30	102.00	125.00	145.00
40	120.00	145.00	164.00
50	136.00	164.00	190.00
60	151.00	190.00	210.00
75	191.00	210.00	240.00
100	.....	245.00	270.00

The above prices are based on the old winding being in the frame and the scrap being retained by the repair shop. If the machines are stripped when received an additional charge will be necessary to cover the scrap value and the cost of redesigning the windings.

Wound Rotors.—The above prices are for rewinding the *stator only.* On slip-ring motors or other types of motors with wound rotors the cost of rewinding the *rotor only* is approximately the same as rewinding the stator.

Squirrel-Cage Rotors.—On squirrel-cage rotors, the joints between rotor bars and end rings quite frequently get burned. The cost of acetylene welding these joints, turning and rebalancing rotor varies considerably with different types. An approximate cost for this work is between 15 and 20 per cent of the stator rewinding price.

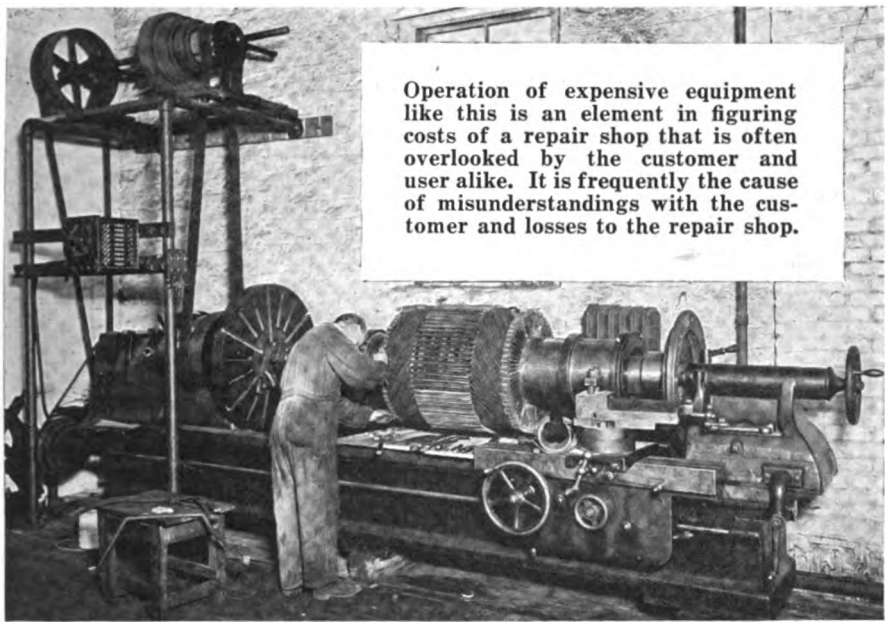
Bearings.—Bearings in motors range all the way from the cheap, die-cast composition factory bearing to the special bronze and split babbitt bearings. An approximate cost *per bearing,* including taking out the old bearing and installing the new one, will be 7½ to 10 per cent of the stator rewinding price.

High-Voltage Windings.—Stators above 550 volts take a special insulation and will vary considerably in cost with different makes. The cost of rewinding 2,300-volt stators will average 20 to 25 per cent higher than the listed prices. Above 2,300 volts each job will be priced specially.

Direct-Current Armatures.—It is difficult to make a schedule of prices for rewinding of direct-current armatures, as there is considerable variation in different makes. However, the above schedule will be approximately correct for rewinding *modern* direct-current armatures, exclusive of any repairs to commutators.

Single-Phase Rotors and Stators.—There are so many varieties of single-phase motors on the market that the cost of rewinding each type must be estimated separately. The above schedule will, however, serve as a rough guide when it is remembered that a single-phase motor is about 50 per cent larger than a three-phase machine of the corresponding rating.

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Operation of expensive equipment like this is an element in figuring costs of a repair shop that is often overlooked by the customer and user alike. It is frequently the cause of misunderstandings with the customer and losses to the repair shop.

amount of this miscellaneous material, a regular requisition would be issued. The "budget" scheme is simply used for the small accounts.

In the February, 1922, issue of INDUSTRIAL ENGINEER a schedule of repair prices was published. A similar schedule of rewinding prices accompanies this article, which has been worked up from the costs of several shops and used where estimates and quotations are required on a repair job. Such a schedule can be depended upon, however, only for an average cost on a straight rewinding job on a standard machine, since costs will vary with different ages, makes and types of motors. For the later designs of polyphase stators this schedule of prices will check fairly closely when the stator dimensions and the winding specifications do not differ widely. In the case of old alternating-current machines and practically all direct-current machines, however, there will be a considerable variation in specifications of windings for the same horsepower rating and the same speeds.

One large repair shop has attempted to get around these variations by using a set of curves giving rewinding costs based upon diameter and length of core. This is a step in the right direction, but has the disadvantage that it requires dismantling the motor to give a price which is out of the question in most cases where the customer 'phones or writes in for a hurry-up quotation, giving nameplate data only.

Another factor which neither this scheme nor the horsepower-speed prices take into account is the size, number and shape of slots, which are really the determining factors in the labor cost of rewinding.

Several months ago, in checking some winding costs, I ran across an extreme case of cost variation in this regard. This particular motor was rated at 10-hp., 900-r.p.m., 220-volt elevator duty which would correspond to about a 7½-hp. continuous rating. The labor cost of this machine was extra low, running about the same as a 3-hp., 1,800-r.p.m. motor. At first it was thought an error had been made in the labor cost records, but these were checked and found correct. Further investigation disclosed the fact that there were but 48 coils where ordinarily there would be 72 or 96 in a machine of this rating. In addition, mush coils were used with open slots instead of the customary partially closed slots. This is just a sample of the many things that make it dif-

Schedule of Rental Rates for Generators, Motors, Transformers and Meters Used for Temporary Service

D.C. AND A.C. GENERATORS 110, 220 OR 550 VOLTS			D. C. MOTORS, 110, 220, OR 500 VOLTS—STANDARD SPEEDS			A. C. SQUIRREL CAGE, MOTORS*, 110, 220, OR 440 VOLTS—2 OR 3 PHASE STANDARD SPEEDS			A. C. MOTORS, SINGLE PHASE—STANDARD SPEEDS		
Kw. Rating	One Month or Less	Each Succeeding Month	Hp. Rating	One Month or Less	Each Succeeding Month	Hp. Rating	One Month or Less	Each Succeeding Month	Hp. Rating	One Month or Less	Each Succeeding Month
3	$ 10.00	$ 6.00	1	$ 6.00	$ 3.50	1	$ 6.00	$ 3.50	1	$ 8.00	$ 5.00
6	12.00	7.50	2	7.50	4.50	2	7.50	4.50	1½	9.00	6.00
8	15.00	9.00	3	9.00	5.50	3	9.00	5.50	2	11.00	6.50
10	18.00	10.00	5	11.00	6.50	5	11.00	6.50	3	12.00	7.50
12	20.00	12.00	7½	13.00	8.00	7½	13.00	8.00	5	15.00	9.00
15	25.00	15.00	10	15.00	9.00	10	15.00	9.00	7½	20.00	12.00
20	30.00	18.00	15	18.00	10.00	15	18.00	10.00	10	25.00	15.00
30	37.50	22.50	20	20.00	12.00	20	20.00	12.00	15	30.00	18.00
40	45.00	27.00	25	25.00	15.00	25	25.00	15.00	20	40.00	24.00
50	55.00	33.00	30	30.00	18.00	30	30.00	18.00	25	45.00	27.00
60	65.00	39.00	35	35.00	21.00	35	35.00	21.00			
75	85.00	51.00	40	40.00	24.00	40	40.00	24.00			
100	120.00	72.00	50	50.00	30.00	50	50.00	30.00			
150	180.00	108.00	75	75.00	45.00	75	75.00	45.00			
200	240.00	144.00	100	100.00	60.00	100	100.00	60.00			

The rental price on all machines includes rails, or base, starting rheostat or compensator and such pulley as we can furnish from our stock. Alternating current motors up to and including 5-hp. are furnished without starters.

Rental on slow speed and on low voltage machines on application. Rental on transformers, $1.50 per kw. first month; 75c per kw. per month thereafter.

The rental on wattmeters and ammeters is a minimum charge of $5.00 for first month or lesser period on instruments valued at $30.00 or less. Rental on larger sizes on application.

*For slip ring motors the prices are 25 per cent higher than those listed.

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What the vault is to a jeweler like Tiffany, this storeroom is to the repair shop. When open to everyone it's a liability; but properly guarded, it's the control on avoidable losses, and waste.

ficult to make up any winding cost schedule.

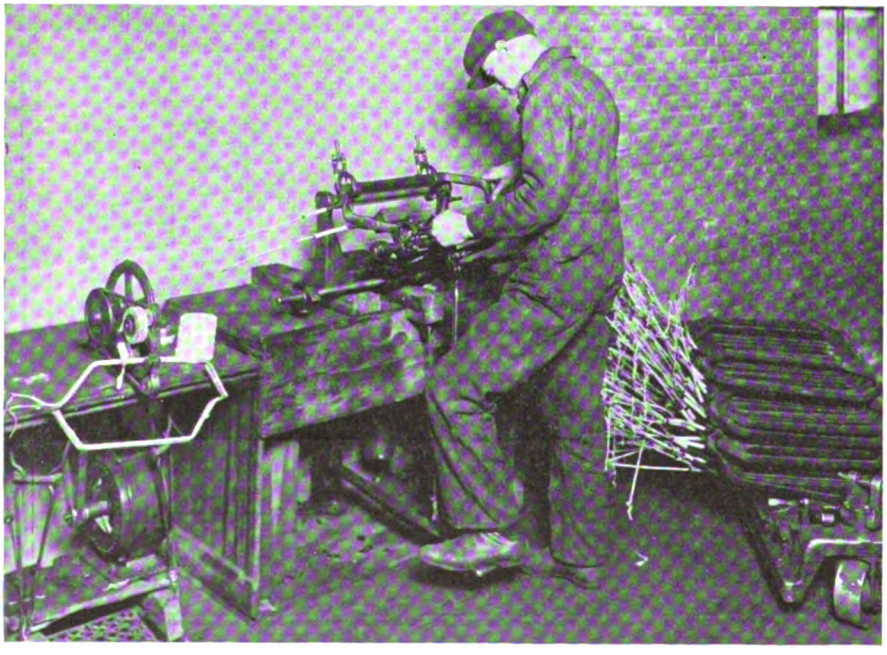
In the case of direct-current and single-phase motors, there is even a greater variety of types and construction, especially with direct-current, as they represent such a wide span of years in design.

We have the same variation to contend with in the cost of bearings. For example, a certain die-cast white metal bearing can be purchased for $1.06, while a similarly rated motor of another make has a complicated split babbitted bearing which will take almost a day's time for a machinist to babbitt and machine, besides using an amount of babbitt which alone would cost more than the die-cast bearing. Between these extremes is the bronze bearing machined to order from cored bushing stock.

In our work we use the accompanying schedule for approximate quotations when these are required and put each job through on a cost-plus basis and bill accordingly. We have found that a customer is ready to pay for a quality job that can be depended upon and stands up in service. When work is done on this basis and the confidence of the customer is secured, prices are seldom called for in advance. Moreover, so much of the work of a small repair shop is only the replacing of a few coils or the location and correcting of winding troubles that the big problem is the working out of an equitable method for charging for material and labor so as to include the proper amount of overhead and a reasonable profit. This is largely a matter of experience and good judgment where skilled men are employed.

In view of the wide variation in analysis of costs, however, I believe that a discussion of methods used and the equipment employed in repair shops would be of interest and profit to all concerned, and I hope that readers of INDUSTRIAL ENGINEER will present their views on the subject for publication. I would particularly welcome comments on the viewpoints which I have here presented.

Coil making is an art that can be greatly refined when suitable machines are provided. Good coils properly formed not only make a good winding job possible but save a lot of the time of the man who inserts them.



The Coil-Windin' Man

Here's a little jingle that is just as true in fact as it is in rhyme.

When motors are stoppin',
Wherever he is,
He's right there a-hoppin',
To keep 'em in biz;
He knows every part of
A motor's inside,
An' harks to the heart of
Her hummin'—with *pride!*

No matter what *make* of a motor it be,
He knows all about it—from A to Z;
An' if it needs *fixin'*—well, fix it he *can*—
He's *some* motor-fixer—the coil-windin' man!

He's always a-bustle,
With "ginger" an' "snap";
His job's to keep motors
From goin 'to "scrap,"
He turns his wise eyes on 'em—
And grins a broad grin—
You bet he is *wise* to 'em—
Outside an' in!

No matter what's *ailin'* them—take it from *me,*
He'll *fix* it—whatever the trouble may be!
He's *some* little fixer, and if *anyone* can
Make good on a job—it's the coil-windin' man!

If you will paste this up in your repair shop, I think it will serve as a little recognition that is due your coil-winding man. It is presented with acknowledgment to the author, James Edward Hungerford, Los Angeles, Cal.

Practical Pete

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WHAT IS INCLUDED in maintenance work? How is it handled in different plants? How often are inspections made on different equipment? What are the most frequent causes of motor failures? What is the character and amount of parts and supplies kept in stock by different companies for maintenance work? These and some fifteen other points in the operation and maintenance of systems in 74 industrial works are answered in detail in this article. It's the first analysis of this kind that has been made heretofore and will be a regular feature of every January issue of Industrial Engineer.

This is a Report on

Practice in Maintenance Work

Showing How 74 Companies Handle Inspections, Repairs and Maintenance Supplies

By E. H. HUBERT
Associate Editor, Industrial Engineer



Work in the repair shops is curative and only one phase of maintenance—adequate inspection is preventive and reduces extensive repair costs to a minimum.

MAINTENANCE of electrical and associated mechanical systems in industrial works is a broad subject, as long and as wide as the area covered by the structures in which the work of production is carried on, as complicated as the equipment and processes that are used. It is less organized than the work of production at machines, yet of equal importance and an essential element in a program of production at the most economical cost per unit of product made.

In this article an analysis is made of maintenance procedure and practices in 74 works along the line of power service from the main switchboard along feeder and distribution circuits, through control equipment and motors, through bearings, pulleys, belts, shafting and speed changing equipment and other parts of the mechanism of power service operated by the motor down to the pulley or spindle of the machine engaged in a process of production. In this line of power service is also included those elements of service to machines and departments of production represented by material handling equipment such as conveyors, elevators, cranes, electromagnets, electric storage battery trucks and the like—equipment that is operated by motors or electrical energy and renders a service that fits in between steps of specialized production at machines.

The maintenance procedure embraces work done on the job in this line of power service and that which requires a specially equipped repair shop for making extensive repairs or rebuilding the equipment.

The seventy-four industrial works that are embraced in this report were chosen among those that represent large area, devoted to production processes and show a pride in good operating methods and good products. They range in size from 4,500 motors with a total rating of 45,000 hp. and use 11,000,000 kw.-hr. per year in electrical energy, to rather small plants where the nature of the product requires a relatively small amount of power. There are thirty-one plants in the group that use over one million kw-hr. per year, which will be called in this article the class A division. There are eleven that use over 500,000 kw.-hr. and will be called the class B division. Those that use less than 500,000 kw.-hr. will be called the class C division. The works all together represent a total installation

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How Maintenance of Electrical and Associated Mechanical Systems Is Handled in 74 Works

IN THIS TABLE an analysis is presented of the maintenance, repair and stock-keeping practices of industrial works that cover a large floor area with electric service in all departments and also operate cranes, conveyors, elevators and material handling equipment.

AN INTERPRETATION of the figures and statements is given on pages 27, 30, 31 and 36 under the following headings: Motor failures, repair and inspection organizations, numbers of men in inspection crews, frequency of inspection and overhauling, amount of

Plant No.	GENERAL PRODUCTS MADE	Power Used	CONNECTED MOTORS								LAMPS			MOTOR FAILURES			Repair Dept.	
		KW-Hrs. Per Year	Number of Motors	Total H. P.	Voltage	A. C. or D. C.	Largest Size, H. P.*	Smallest Size, H. P.*	Number of Motors Under 5 H. P.*	Kind of Drive* (b) Belt; (c) Chain; (d) Gear, or Direct.	Number	Average Size, Watts	Renewals Per Year	Failures Per Year	Burnouts That Require Rewinding	Chief Cause of Motor Failures	Do You Repair and Rewind All Electrical and Mechanical Equipment?	Do You Make Your Coils?
	BRASS AND BRONZE PRODUCTS																	
1	Plumbing and gas goods	1,800,000	174	1230	440	A.C.	40	1/6	85	141b, 1c, 32d.	1600	60	2000	½	½	Starting coil burned out on single phase	Partly	Yes
2	Grease cups, oiling devices	199,000	17	850	220	A.C.	75	½	3	9b, 8d.	700	100	300	0	0		No	No
3	Cast brass, bronze, aluminum		14	190	220	A.C.	20	½	6	14b.	160	60	40	¼	0	Worm bearings	Yes	No
4	Brass and silver pens and pencils	710,400	172	1557	220	A.C.	200	1/16	100	140b, 32d.	1466	(25 to 200)	1058	24	5	Small motor on direct drive	No	No
5	Brick and tile	432,000	8	365	460	A.C.	250	7	0	5b, 2c, 1d.	100	40	200	0	0		No	No
6	Brick and tile	420,000	12	345	440	A.C.	150	5	0	6b, 5d, 1c.	100	40	100	4	2	Dirt and worn bearings	No	No
7	Cement, white portland	3,000,000	39	1480	440	A.C.	150	2	2	29b, 7c.	450	60	900	Few	3	Bearing, fuse or breaker failing	Yes	No
8	Chemicals and dyes		72	1020	220	A.C.	40	½	20	72b.	600	40	700	1	1	Worn bearing	Partly	Yes
9	Coal mining, bituminous	4,350,000	325	2000	2200 440 250	A.C. A.C. D.C.	290	1/8	160		4000	60		300	125	Bearings, oil dust	Yes	No
10	Coal mining, bituminous	600,000	14	441			300			2d.				5	1	Grease, low voltage	No	No
11	Coal mining, bituminous		14	250	250	D.C.	50	2	4	12d.	75	60		5	5		No	No
12	Copper smelting	500,000	18	444	(2200) 220	A.C.	150	5	0	11b.							Yes	No
13	Electric generators, turbines, Motors and small products	11,000,000	4500	45,000	600	A.C.				95%d.						Metal chips and cutting liquid	Yes	Yes
14	Electric generators, turbines, Motors and small products		975	4,500	230	D.C.	300	¼	400	465b, 40c, 468d.				15	6	Overloads	Yes	Yes
15	Electric generators, turbines, Motors and small products	960,000	161	1,250	220	A.C.	150	1/6	20	100b, 61d.	1400	86	1700	8	2	Single phasing	Yes	Yes
16	Electric generators, turbines, Motors and small products	240,000	120	350	(110) 220	A.C.	20	1/10	90	90b, 30d.	570	50-100	1200	4	2	Probably overloads	Partly	Some
17	Electric generators, turbines, Motors and small products	120,000	125	500	220	Both	100	1/6	90	70b, 1c, 44d.	275	75	125	2	½	Dirt and oil	Yes	Yes
18	Electric lifting magnets and meters	85,000	24	142	110 to 440	AC & DC	30	¼	14	12b, 12d.	175	40-60	250	0	0		Partly	Yes
19	Electric motor-generators	26,000	8	42	220 220	A.C. D.C.	7½	½	5	8b.	36	100	12	¼	0		Yes	Yes
20	Electric meters	75,000	30	500	440	A.C.	30	½				75		1	1		No	No
21	Fertilizer, commercial	291,200	25	585	220	A.C.	125	5	0		150	50	300	1	1		No	No
22	Fruit cannery (total of 6 plants)[6]	155,000	98	485	220	A.C.	20	1/6	48	90b, 8d.	1208	50 - 75	585	2	2	Lightning and short circuit	No	No
	IRON AND STEEL PRODUCTS																	
23	Pig iron		16	570	220	D.C.	50	3	3	4b, 12d.	380	50-300	$600	50	6	Oil creepage with coke dust	Yes	No
24	Steel castings	113,700	49	719	230	D.C.	225	½	32		270	300	70	19	13	Grounds	Yes	No
25	Hoists, locomotives, coal and cement machinery, fans	1,000,950	208	2950	440	A.C.	225	½	32		980	200	245	54	22	Grounds and oil	Yes	No
26	Steel plates	7,981,441	726	16,172	250	D.C.	200	⅛	150	mostly d.	2090	200	4971	400	60	Oil, defective insulation, mech. failures, overloads	Yes	No
27	Steel castings	7,218,774	391	7340	240	D.C.	100	¼	37	150b.			8587	105	42	Shorts in commutator, grounds	Yes	No
28	Steel castings	3,996,000	72	630	220	A.C.	150	½		28b, 46d.		50-200	$350	2	1/5	Worn bearings, A.C., Oil, D. C.	Yes	No
29	Castings, machinery	2,000,000	140	2391	440	A.C.	225	½	30	5b, 1c, 134d.	623	200	1250	82	17	Grounds	Yes	Yes
30	Locomotive stokers and coal pushers	721,000	120	1200	220	A.C.	100	½		110b, 1c, 9d.	900	100	700		6	Cleaning neglected	No	No
31	Machinery	1,400,000	1000	8825	440	A.C.	150	1/6	600	790b, 20c, 190d.	10,000	40	15,000	150	90	Burn outs	Yes	No
32	Automobile frames	2,448,000	281	4049	440	A.C.	150	¼	90	210b, 5c, 66d.	2130	200	1200	25	5	Single phasing, fumes	Yes	Yes
33	Valves, pipe fittings, etc.	5,000,000	233	3268	220	D.C.	720	1/10	100	156b, 2c, 75d.	3400	75	7500	3	2	Overload, commutator & iron dust	Yes	Yes
34	Gate valves	120,000	13	297	220	A.C.	50	1	2	10b, 3d.	200	50-75	144	0	0		No	No
35	Nuts and bolts	2,048,000	330	3698	220 230	A.C. D.C.	200	⅛			2570	60 200 to	5098	100	24	Insulation failure	No	No
36	Auto and bicycle accessories	3,400,000	200	3000	440	A.C.	100	½	50	150b, 3c, 47d.	800	500					Partly	No
37	Rifles and pistols	900,000	275	2500	220	A.C.	150	¼	12	275b.	600	60	4	5	2	Single phasing	[1]Yes	Yes
38	Typewriters	375,000	75	443	230	A.C.	50	⅛	30	65b, 10d.	1400	40 - 75	2400	0	0			No
39	Leather, sole		38	662	440 110	A.C. D.C.	100	1	9	35b, 3d.	520	50	250	3	1	Insulation failure	Partly	No
40	Leather, sole	1,948,400	98	1477	550	A.C.	65	¼	16	58b, 34c, 6d.		50	1784		1	Moisture, hot bearing	Partly	No
41	Leather, heavy upper	1,500,000	150	700	440	A.C.	75	½		37b, 110c, 3d.	500	100	500	8	8	Moisture	No wd	No
42	Leather shoes, women's and children's	415,000	118	205	220	A.C.	20	½	100	25c, 38g, 55d.	700	40	750		0	Worn bearing	No wd	No
43	Leather boots and shoes	360,000	40	325	550	A.C.	30	¼	21	25b, 15c.			300		30		No	No

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maintenance stock, and responsibility for maintenance, production and non-interruption of service. The data in the tables has been compiled from individual reports from seventy-four companies in a wide variety of industries.

In some cases special reference was made in the reports received to details of practices or explanations offered covering the figures given. The following notes explain such items and bear marks in the table corresponding with the small reference figures shown here:

* In some cases these figures have been estimated.
[1] No heavy equipment repaired.
[2] Machine operator is responsible.
[3] Locomotive motors.
[4] Magnet Wire.
[5] Keep one month's supply of all materials.
[6] Total of figures for six plants each having from 51 h. p. to 100 h. p. installed in motors.
[7] Surplus from war time.
[8] Safety inspectors only.
[9] 1,000 links and 100 refillable fuses.
[10] No rewinding done.
[11] Two complete bearings per motor kept in stock.

INSPECTION WORK					OVER-HAUL'NG		MAINTENANCE SUPPLIES KEPT IN STOCK													RESPONSIBILITY FOR MAINTENANCE	
How Many Men Employed as Inspectors?	Frequency of Inspection Weeks				How Often Is Equipment Thoroughly Overhauled?	When Is Overhauling Done?	Wire	Brushes	Babbitt, Lbs.	Solder, Lbs.	Tape, Rolls	Oil, Bbls.	Conduit and Fittings	Fuses	Lamps	Reflectors	Bells	Pulleys	Chains	Gears	Title of Man in Charge of Maintenance	Is He Also Responsible for Production and Non-interruptions of Service? If not, Give Title of Man in Charge of This Work
	Motors	Control	Cranes	Material Handling Equipment																	
0	.....	.....	.....	.....	Yearly	Dec.	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....
0	4	.....	.....	.....	.....	.....	2000′	Few	...	...	25 rolls	1	.....	100	350	24	1500′	200	.....	.....	Supt.	.....
1	1	1	.....	.....	6 mo.	Aug. Feb.	0	Set	0	0	2 lb.	1	0	50	100	0	0	50	0	0	Asst. Supt.	Yes
2	.....	.....	.....	4	Yearly	Jan. 1.	2000′	.....	25	25	5 lb.	1	3000′	2 mo.	2 mo.	.....	1 mo.	1 mo.	.....	.....	.....	.....
0	See[2]	.....	.....	.....	Yearly	Fall	0	Set pr. mtr.	0	0	.....	...	None	.....	75	0	0	0	Links	0	Master Mechanic	Supt.
0	1	.....	.....	.....	.....	As needed	Little	5	0	0	Few rolls	1	None	Few	1 case	0	0	0	0	0	Asst. Gen. Mgr.	Yes.
3	Daily	Daily	.....	Daily	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Supt.	Yes.
2	2	2	2	.....	.....	As needed	400′	18	50	20	24 rolls	½	150′	12 ea.	100	12	1000′	20	.....	.....	Elec. Engr.	No.
12	1	.....	.....	.....	.....	As needed	[4]600 lb.	500	...	100	50	....	150	.....	.....	.....	.....	.....	.....	.....	Elec. Engr.	Gen. Mgr.
1	[2]Daily	.....	.....	Daily	.....	As needed	.....	.....	...	...	20 lb.	15	.....	.....	.....	.....	.....	.....	.....	.....	Machine boss.	Yes.
0	.....	.....	.....	.....	.....	.....	.....	.....	50	20	50 lb.	....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Electrician	Supt.
3	.....	.....	4	.....	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Foreman elec.main.	Not prod.
....	.....	.....	.....	.....	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Maint. Supervisor	Yes.
2	.....	.....	1	.....	.....	As needed	.....	.....	...	...	.....	...	.....	.....	500	5	.....	.....	.....	.....	Electrician	Supt.
1	4	.....	.....	.....	.....	As needed	0	0	0	0	0	1	Small amt.	400	150	100	300′	25	.....	.....	No title	Yes.
1	26	26	26	.....	.....	Never	.....	.....	...	...	.....	...	Considerable	.....	.....	.....	.....	.....	.....	.....	Supt.	Yes.
2	1	1	1	.....	.....	As needed	100′	Set pr. mtr.	50	50	25 lb.	3/5	100′	300	60	0	125	0	0	0	Supt.	Yes.
1	.....	.....	.....	.....	.....	.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Supt.	Yes.
1	52	.....	.....	.....	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1	1	1	.....	Daily	6 mo	Winter & S	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Supt.	Yes.
0	Daily	.....	.....	.....	Yearly	Spring	0	0	30	5	9 rolls	7/10	0	143	111	0	0	0	0	0	No title	Yes.
3	Twice daily	Twice daily	Twice daily	Twice daily	3 yr.	.....	2000 lb.	3 sets pr. m	100	25	25 lb.	3	500′ 300 fitgs.	80	168	10	.....	.....	.....	75	Elect., M. M. and Steam Engr.....	Yes.
5	1	1	2	4	.....	As needed	3000′	70	...	25	25 lb.	....	500′ 200 fitgs.	25 ea. size	24 ea. size	....	.....	15	.....	spare	.....	.....
6	½	½	.....	.....	.....	When poss	55,000′	5858	...	200	2000 lb.	...	.....	3000	2104	50	.....	.....	.....	1000	.....	.....
6	Daily	Daily	Daily	.....	.....	As needed	2000′	Large no.	500	50	200 lb.	5	400′	.....	336	0	500′	0	.....	.....	.....	.....
1	Daily	10	1	.....	W'kly	Week end	Some	1 or 2 sts.	25	15	10 lb.	1	{Few angles and elbows}	110	100	Few	100′	Few	2	2	Elec. and Mach'st	Master Mech.
5	Daily	1	½	.....	.....	As needed	400 lb.	330	50	20	60 lb.	1	400′	.....	700	0	100′	0	0	60	Supt. Light, Heat and Power.....	Prod. Supt.
2	1	1	1	.....	.....	As needed	See[3]	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Shop Engr.	Supt.
3	4	4	4	4	Yearly	Cont.	$1500	$20	...	...	$100	2	$200	200	4000	0	.....	.....	.....	.....	Works Mgr.	Yes.
....	1/7 &2	1/7 &2	1	1/7& 1	.....	As needed	1500′	200	300	100	50 lb.	10	1500 pieces	500	250	0	2500′	150	0	0	Master Mech.	Yes.
3	Daily	Daily	Daily	....	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Supt. of Maint.	General Supt.
....	1	17	.....	.....	.....	.....	0	0	10	0	3 rolls	1/5	0	36	48	0	0	3	0	0	Works Mgr.	Yes.
....	Daily	Daily	Daily	Daily	.....	As needed	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
0	.....	.....	.....	.....	.....	.....	.....	.....	...	...	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	Plant Engr.	Supt.
....	.....	.....	.....	16	Yearly	.....	2000′	100	200	200	[7]400 lb.	1	2500′	10,000	1500	1000	.....	500	0	0	Electrician	Prod. Engr.
2	4	4	.....	4	.....	As needed	100lbs.	0	20	10	5 lb.	1/10	None	50	60	12	....	Few	0	0	Wks. Engr.	Yes
[11]4	2	2	1	.....	.....	.....	2500′	St. pr. mtr.	200	25	15 lb.	1	800′	[9]1000	100	....	500′	100	150′	25	Plant Engr.	Supt.
0	1	4	4	4	.....	.....	10000′	.....	...	25	50 rolls	3/5	5000′	$700	250	....	.....	50	.....	.....	Chief Engr.	Yes.
2	1	1	.....	1	Yearly	.....	1000′	.....	200	50	25 lb.	5	0	500	500	25	1000′	50	50	50	Elec. Engr. & Mast. Mechanic.....	Yes.
1	4	.....	.....	2	6 mo.	Apr. Oct.	3500′	.....	10	20	10 lb.	2	.....	.....	200	40	500′	25	0	0	Engr.	Yes.
1	1	1	.....	.....	.....	As needed	10′	1 set	50	5	5 lb.	....	.....	100	400	....	.....	.....	.....	.....	Chief Engr.	.....

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This Table is continued from pages 28 and 29

Plant No.	GENERAL PRODUCTS MADE	Power Used	CONNECTED MOTORS								LAMPS			MOTOR FAILURES			Repair Dept.	
		KW-Hrs. Per year	Number of Motors	Total H. P.	Voltage	A. C. or D. C.	Largest Size, H. P.*	Smallest Size, H. P.*	Number of Motors Under 5 H. P.*	(b) Belt; (c) Chain; (d) Gear, or Direct.	Number	Average Size, Watts	Renewals Per Year	Failures Per Year	Burnouts That Require Rewinding	Chief Cause of Motor Failures	Do You Repair and Rewind All Electrical and Mechanical Equipment?	Do You Make Your Coils?
44	Leather, substitute heeling and fibre	809,000	9	375	2500 250 440	A.C. A.C.	300	7½	0	8b, 1d.	30	200–50	75	0	0		No	No
45	Lumber, sash, doors, boxes	3,000,000	247	6484	220 110	A.C. D.C.	150	½	....	210b, 1c, 46d.	.....	50–400	2000	0	0	Clutch failure, left in starting pos.	Partly	No
46	Lumber, all kinds	488,670	23	525	440	A.C.	150	2	2	22b, 1g.	96	60	75	½	½	Overload and vertical drive	No	No
47	Lumber	.....	31	422	.....	A.C.	35	5	....	.....	500	50	200	2	1/15	Overload	No wd	No
48	Meat products	300,000	50	375	220	D.C.	25	⅛	25	12b, 3c, 35d.	2000	60	.....	25	2	Moisture	No	No
49	Meat, slaughtering	750,000	15	350	220	A.C.	125	2	3	11b, 1c, 3d.	500	75	500	3	3	Moisture	No	No
50	Paper	4,572,000	86	1915	550	A.C.	400	¼	35	67b, 19d.	1400	25-60	5000	2	0	.....	Partly	No
51	Paper, fine writing	1,700,900	28	806	600	A.C.	100	5	0	6b, 22d.	.....	.....	.....	2/5	2/5	Dirt, oil, chemicals and water	No wd	No
52	Paper, writing	960,000	10	428	2200 220	A.C.	200	½	3	9b, 1d.	125	25	.....	Few	0	Wear of fingers in starters	No	No
53	Paper, rope and jute	652,000	18	200	220	A.C.	100	¼	4	18b.	290	40	1650	1	....	.....	No	No
54	Pencils	1,096,000	54	1100	230	D.C.	60	½	....	48b, 6d.	1100	40	800	1/3	¼	Detoriation of insulation	No	Yes
55	Railroad shop	1,070,060	204	2555	230	D.C.	100	1/5	30	67b, 14c, 123d.	18,000	60	25,000	20	6	Grounded coils and power fluctuate	Yes	Yes
56	Rubber tires	1,800,000	50	1650	440	A.C.	600	½	....	15b, 3c.	500	100	800	1	1	Overload	No	No
57	Rubber tires and other products	1,322,000	29	927	440 230	A.C. D.C.	250	1/30	16	21b, 1c, 7d.	244	100	8	4	1	Worn bearing	No	No
58	Rubber tires and tubes	400,000	15	385	....	D.C.	150	¼	6	6b, 2c, 9d.	100	200	170	5	2	Worn out	No	No
59	Rubber boots, shoes and clothing	.....	93	1350	550 110	A.C.	500	1/10	....	85b, 8d.	2000	40	2000	3	1	Water	No	No
60	Soap, all kinds	.....	200	1400	440 220	A.C.	100	⅛	87	130b, 7c, 63d.	500	60	125	10	10	Low voltage	No	No
	TEXTILES																	
61	Catton goods	8,000,000	950	9000	220 550 2300	A.C.	200	½	350	.....	10,000	50-75	.....	10	10	Wear on windings	Yes	No
62	Cotton yarns	2,250,000	28	1100	220 2300	A.C.	250	5	0	.....	1000	25–100	750	0	0	Lightning and surges	M'tly	No
63	Wool tops	2,048,410	38	.....	440	A.C.	100	3	5	6b, 25c, 7d.	427	40–100	275	1	1	Bearings worn	No	No
64	Woolen goods	544,000	63	500	240	A.C.	15	1	4	58b, 1c, 4d.	1090	50-400	300	2	½	Worn bearings, flyings	No	No
65	Silks, broad	580,000	576	650	220	A.C.	20	1/40	515	11c, 500d.	2576	60	1160	17	6	Overload due to faulty adjustment	Yes	Yes
66	Silks, broad	68,300	149	60	220	A.C.	1	1/3	140	20b, 120d.	350	40	100	⅛	⅛	Lack of oil	Partly	No
67	Tobacco, plug and cut	180,000	26	252	440	A.C.	20	⅛	2	26b.	500	75	100	0	0	.....	No	No
68	Electric generators and motors	8,720,000	3500	19000	230 440	D.C. A.C.	700	1/50	290	1900b, 100c, 1300d	15000	75	17000	2000	200	Shorted and grounded con. and windings	Yes	Yes
69	Yarn and cloth	29,000,000	1577	17812	.....	.....	.....	.....	.....	.....	13,000	60	1300	Few	Few	Lightning	Yes	Yes
70	Building materials	2,184,000	466	8484	125 110 220 440	D.C. A.C.	150	⅛	55	.....	6000	60	1200	12	2	Poor machine operation	Yes	Yes
71	Electric trucks	450,000	407	2400	440	A.C.	400	¼	73	450b, 100c, 82d	1875	200	600	30	10	Dust and dirt	Yes	Yes
72	Cotton cloth	4,660,600	81	1821	110 550	D.C. A.C.	75	⅛	8	All b.	810	100	1050	2	Few	Low voltage and overloads	No	No
73	Floor and wall tile	450,000	92	775	220 110	A.C.	25	1	20	10b, 70d.	600	60	500	14	4	Low voltage	Yes	No
74	Shoes	1,200,000	649	1877	220	A.C.	100	1/10	560	80%b, 15%c, 5%d.	6000	25	2500	5	1	Bearings and grounds	No wd	No

of 209,925 hp. in 21,244 motors that use over 147,000,000 kw.-hr. of electrical energy per year. The average consumption per plant is about 2,000,000 kw.-hr. and the average consumption per installed horsepower is about 700 kw.-hr. Thirty-five of the plants have over 1,000 hp. installed in motors.

Motor Failures.—Of the causes for motor failures, worn bearings and moisture were responsible for the largest share on alternating-current motors. On such machines the causes of failures were reported as follows: Worn bearings, 12; moisture, 5; oil, 1; chemicals, 1; fumes, 1; dirt, 6; overload, 5; fuse blown on one-phase (single-phasing), 3; grounds, 6; starter fingers burned, 1. On direct-current machines, oil and commutator troubles caused eight failures; overloads, 3; grounds, 3; dust, 1. Out of 1,534 failures, 504 motors required rewinding. The highest percentage of failures was 50 on 16 motors in a pig-iron furnace company which is plant No. 23 in the table. The motors are 220-volt, direct-current. Oil creepage and coke dust are responsible for the large number of failures. Due to the difficulty of operating under such conditions, the equipment in this plant is inspected twice a day. Next to this record comes a failure of 300 in 325 motors in a coal mine which is No. 9 in the table. These failures were on 220-volt and 440-volt alternating-current motors and on 250-volt direct-current locomotive motors. They were caused by worn bearings, oil and dust. Another case shows 82 out of 140, alternating-current, 440-volt motors in a plant for iron and steel castings and machinery reported as No. 29 in the table. This was in spite of daily inspection by fire inspectors. Several of the plants making heavier iron and steel products showed a large percentage of failure which reflects the particular conditions in these plants. A meat-

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See explanatory notes on page 29

How Many Men Employed as Inspectors?	INSPECTION WORK: Frequecy of Inspection Weeks: Motors	Control	Cranes	Material Handling Equipment	OVER-HAUL'NG: How Often Is Equipment Thoroughly Overhauled?	When Is Overhauling Done?	MAINTENANCE SUPPLIES KEPT IN STOCK: Wire	Brushes	Babbitt, Lbs.	Solder, Lbs.	Tape, Rolls	Oil, Bbls.	Conduit and Fittings	Fuses	Lamps	Reflectors	Belts	Pulleys	Chains	Gears	RESPONSIBILITY FOR MAINTENANCE: Title of Man in Charge of Maintenance	Is He Also Responsible for Production and Non-interruptions of Service? If not, Give Title of Man in Charge of This Work
	Daily	Daily	.....	.....	.....	As needed	0	2 sets 50	...	...	.....	1	.....	50	25	....	.50′	....	....	.....	Master Mech.	Not for prod.
2	Daily	Daily	.....	.....	.....	As needed	400′	Set pr. mo.	...	...	35 lb.	2	.....	.....	130	Few	.....	9	....	.....	.....	.....
1	½	12	.....	.....	3 mo.	.....	600′	.....	...	4	6 rolls	2	Some	24	100	....	500′	10	....	.....	Engr.	.....
1	1	.....	.....	.....	.....	As needed	300′	.....	50	10	5 lb.	1	None	400	200	0	600′	20	....	.....	.....	.....
2	1	.....	.....	.....	.....	As needed	Some	100	..	50	10 lb.	1/5	Small stock	200	350	100	.....	25	....	.....	Electrician	Supt.
0	Daily	26	.....	1	.....	As needed	.....	.....	20	10	6 lb.	1/5	200′	4 ea.	200	3	5 ea.	0	links	0	No title	Yes.
2	.....	1	.....	1	.....	As needed	500′	Set pr. mo.	0	25	100 lb.	3/5	1800	2000	1000	50	0	0	0	0	Mgr. of Maint.	Mgr. of Prod.
1	Daily	Daily	.....	Daily	Yearly	.....	5000′	100	500	25	15 lb.	5	300′	150	200	25	1000′	100	75	100	Asst. Supt., Mast. Mech.	Yes.
1	52	.....	.....	.....	Yearly	July	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Mast. Mech.	No.
1	Daily	.....	.....	.....	Mthly	.....	0	Few	100	10	.....	0	0	Few	Few	0	0	0	0	0	.....	.....
2	.....	.....	1	.....	Yearly	.....	500′	.....	0	10	10 lb.	1/10	.....	200	300	25	0	4	0	0	No title	Yes.
4	1	1	1	1	.....	As needed	Little	Few sets	.....	.....	.....	1	Few	.....	.....	.....	.....	.....	.....	.....	Man in Elec. Dept.	Man in Mech. Dept.
1	1	1	.....	.....	.....	As needed	500′	2 sts pr. mo	100	50	500 rolls	1/5	$2500 stock	510	5000	200	400′	12	1	6	.....	.....
1	1	4	.....	.....	Yearly	December	0	Set pr. mo.	200	25	10 lb.	1/5	None	.....	12	0	0	0	0	0	Mast. Mech.	No.
0	Daily	1	.....	.....	2 yrs.	.....	1000′	6 sets	50	10	.....	1/3	4000′	100	100	80	.....	24	.....	.....	.....	.....
1	1	4	.....	.....	6 mo.	Jan. & Jul	.....	Few pr.mo.	100	25	10 rolls	1/5	$150	.....	50	25	Little	.....	.....	.....	Mast. Mech.	Factory Mgr.
7	1	1	.....	1	Yearly	Winter	1000′	Set pr.mac.	100	50	25 rolls	2	$500	250	500 250	100	500′	100	$1000	$1000	Mast. Mech.	Yes.
6	1	4	.....	.....	Yearly	.....	2000 lb.	Set pr.mot.	See 11	100	50 lb.	10	$1000	2000	1000	200	$1000	$2000	.....	.....	Mech. Supt.	Yes.
3	1	1	.....	1	.....	As needed	.....	.....	...	...	.....	....	.....	.....	.....	....	.....	.....	.....	.....	Mast. Mech.	.....
4	1	1	.....	.....	Yearly	.....	.....	.....	...	25	50 rolls	....	.....	.....	500	0	....	25	3	0	Supt.	Yes.
1	1 & 4	0	0	4	.....	As needed	Little	1 extra set	100	10	3 lb.	....	Small supply	.....	300	0	0	.....	0	....	No title	Yes.
6	1	1	.....	.....	2 mo.	As needed	5000′	24	0	5lb	20 lb.	1	500	$200	$200	200	.....	.....	.....	50	.....	.....
0	13	13	.....	.....	Yearly	Jan.	0	0	0	0	0	0	0	100	100	12	50′	4	0	24	Supt.	.....
1	2	.....	.....	.....	.....	As needed	0	0	Sm	Sm	2 rolls	Sm	0	50	12	..	0	Some	0	0	Engineer	Supt.
7	Daily	Daily	1	1	.....	.....	500 lb.	800	...	60	40 lb.	....	20,000′	10,000	5000	800	5500′	.....	0	0	No title	Yes
6	1	M'nly	M'nly	M'nly	Y'rly	August	.....	1 extra set	1M	250	.....	33	.....	.....	.....	.....	.....	.....	.....	.....	Supt. Mech. Dept.	Yes
5	Daily	M'nly	Daily	.....	.....	Monthly	1000 lb.	300 to 400	500	50	200 lb.	2	1000	200	1000	....	.....	.....	.....	30	.....	.....
4	1	1	Daily	.....	Y'rly	1st of Yr.	1500 lb.	500	200	100	50-100lb.	4	.....	500	200	25	600′	100	15	200	Plant Engineer	Yes
3	1	Daily	.....	.....	Y'rly	Spring	Little	9 Sets	...	10	3 lb.	....	.....	.400	50	....	....	....	.....	.....	Chief Elect.	Supt.
1	1	1	.....	1	.....	As needed	0	0	500	20	12	2	0	100	100	0	0	0	150′	50	Mast. Mech.	Yes
2	1	M'nly	.....	.....	.....	.....	20,000	24	100	100	25 lb.	10	3000′	4000	1400	100	5000′	$1500	0	0	Mech. Eng.	Yes

packing plant had 25 failures in 50, direct-current, 220-volt motors, caused chiefly by moisture.

Repair and Inspection Departments. — Some interesting figures were reported regarding repair and inspection departments. The companies were asked for details of attention paid to motors, control equipment, belts, chains, gears, pulleys, and material-handling equipment including cranes, storage-battery trucks, electric hoists, conveyors. Twenty-seven companies said they repair and rewind all electrical and mechanical equipment such as mentioned. Sixteen companies have a repair department for part of their equipment; that which is not regularly repaired by the plant force is usually of large rating. Nineteen of the companies make their own motor coils. Fifty-six companies have regular inspection crews totaling 155 men. In the plants of the Class A division, all but one conduct regular inspections. In this one plant the machines have individual motor drives and the machine operators are responsible for their operation. Three of the plants in Class A division have no inspection crews as such but motors are inspected daily in two of them and weekly in the other. All the other plants, excepting seven, either have a regular inspection crew or make daily inspections. These seven make inspections at regular intervals as follows: Nos. 40 and 48, weekly; No. 2, monthly; No. 66, every 3 months; Nos. 1 and 5, yearly, and No. 11, never.

Number of Men in Inspection Crews.—Although the size of the inspection crews varies widely to meet different conditions, the average number of inspectors for plants of different sizes is variable. By careful estimating on all the plants it was found that on an average one man could handle the inspection work in a plant having 300 hp. in motors; two men, 600 hp.; three

(*Continued on page* 36)

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Comments on Maintenance Work by Readers of Industrial Engineer

Readers of INDUSTRIAL ENGINEER in large works of a wide range of industries, where maintenance of equipment and power service takes on a variety of aspects, were asked the following questions. Their replies are tabulated below under headings corresponding to these questions:

Question No. 1. From your own experience what equipment is most often neglected or abused by an operating organization?

Question No. 2. In what departments of a plant or on what equipment can inspectors and maintenance men show the greatest saving?

Question No. 3. (a) Is the largest amount of maintenance work in your plant on mechanical or electrical equipment? (b) For industrial plants in general how does the general maintenance on mechanical equipment compare with that on electrical equipment?

Question No. 4. Check the following subjects that require the largest amount of the maintenance man's time as a general rule: Motors; control equipment; elevators; cranes; conveyors; lighting; factory call systems; mention any others and indicate order of importance.

Question No. 5. If you were required to check up the saving which can be shown by adequate inspection, general maintenance and overhauling of plant equipment, both mechanical and electrical, which of the following items would you consider the most important?

(a) Saving through prevention of costly breakdowns.

(b) Saving of spoiled material through fewer interruptions of processes.

(c) Saving shown by increased plant production through keeping work constantly moving and in process on machines with shutdowns at a minimum.

(d) Saving in life of equipment and fewer failures through inspections.

Reply No.	Question No. 1	Question No. 2	Question No. 3	Question No. 4	Question No. 5
1	Rubber Mills	Rubber mills and calenders	Mechanical	Motors	Item (d)
2	Power plant by failure to make necessary additions	Departments continuously in operation	(a) Mechanical (b) Mechanical about 25% greater than electrical	Elevators, cranes, conveyors and lighting	Item (d) first, item (a) second
3	That most easily abused	D. C. motors	It depends upon equipment used	Elevators and cranes	Item (b)
4	Manual motor control	Equipment where several machines operate in train	(a) Mechanical (b) Most on mechanical	Control and lighting	Item (d)
5	Lighting most neglected	Motor inspection 50% Safety inspection 50%	(a) and (b) about 50-50	Motors 25%; control 20%; elevators 15%; lighting 20%; factory call systems 5%; fire alarm systems 5% and general 10%	Item (a) first; (d) second; (c) third; (b) fourth
6		Motors, bearings, oiling and cleaning	Mechanical	Motors, control, elevators and lighting	Item (c) first; item (d) second
7	Electrical	Electrical and mechanical	(a) and (b) about 50-50	Motors, control, cranes, conveyors	Items (d) and (a)
8	Motors and lights	Electrical		Motors, lighting, factory call systems	Item (a) first; others important
9	Power and lighting equipment	In repairs to prevent a shutdown	Mechanical and electrical about 50-50	Same as answer to Question No. 1	Items (a) and (c)
10	Saw mills in lumber plants	Planing mill and shipping departments	Mechanical ⅔; electrical ⅓	Control and cranes	Item (c)
11	Electrical	Electrical—when one unit shuts down 15 to 20 men are idle	(a) and (b) about 50-50	Keeping dirt out of motors; checking oiling; repairing compensators	Item (d) first; (c) second
12	Motors and bearings	Controllers, brushes and commutators	(a) Mechanical; (b) neglect of mechanical repairs may be cause of electrical troubles	Motors when abused and neglected, control, cranes	(d) makes (a) possible and (b) and (c) are taken care of by observance of (a) and (d)
13	Motors are most abused in lumber mills	Mechanical department	(a) Mechanical; (b) mechanical costs are highest	Motors	Item (c)
14	Mechanical drives	By changing to electric drives	(a) Mechanical; (b) about 50-50	Conveyor chains, motors, bearings, belts, compensators	Items (d) and (a)
15	Power plant	Prime movers	(a) Mechanical; (b) 50% more than electrical	Control	Items (a) and (c)
16	Mechanical equipment	Preparing or wood department in paper mill	(a) Mechanical; (b) 5 to 10 times more than electrical	Control, conveyors, belting and pumps	Item (a) first; (c) second; (d) third
17	Motors and control	Motors	(a) Mechanical	Motors, control, lighting, factory call system	Item (c)
18	Electrical equipment	Electrical neglect may be more far reaching than mechanical neglect	(a) Mechanical; (b) electrical not as expensive	Motors, control and lighting	Item (c) first; (a) second; (d) third; (b) fourth
19	Electrical equipment	Motors, shafting and belts		Motors, control, lighting	Item (d)
20	Motors from overloads	Motors and control	(a) Mechanical	Motors and control	Item (d) first; (a) second

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Continuation of Comments on Maintenance Work on Page 32

Reply No.	Question No. 1	Question No. 2	Question No. 3	Question No. 4	Question No. 5
21	Electrical equipment	Cranes, motors and control	(a) Mechanical; (b) 30 to 40% more than electrical	Motors, control, cranes, lighting	Item (c)
22	Conveyors and bucket carriers in cement mills	Material handling equipment	50% of repairs chargeable to elevation and conveying		
23	Electrical equipment	Motors and starters	(a) Mechanical; (b) mechanical 75%; electrical 25%	Control, starters, cranes, conveyors, elevators	Item (d) first; (a) second
24	Electrical equipment both neglected and abused	Key motors such as elevators and conveyors carrying materials from or to departments	(a) Mechanical; (b) higher on electrical in proportion to machinery used	Conveyors, grinding mills, elevators, motors, control, lighting	Item (c) first; (a), (b), and (d) important to get the (c) result
25	Production machinery	Machining departments	(a) Mechanical; (b) greater care is given mechanical	Replacing belts, motors, cranes, conveyors, lighting	Item (d)
26	Motor starters	Electrical and mechanical equipment	(a) Mechanical; (b) about two to one	Control, lighting	Item (c)
27	Motors	Power plant	(a) Mechanical	Motors, control, elevators	Item (c) first; (b) second; (a) third; (d) fourth
28	Mechanical equipment		(a) Electrical	Motors, control, elevators	Items (d) and (a)
29	Production machinery	Electrical control	(a) Mechanical; (b) mechanical two to three times more	Control on cranes	Item (d) first; (c) second
30	Electrical equipment	Steam plant	(a) Mechanical; (b) mechanical two to one	Lighting, motors	Item (d) makes savings in (a), (b) and (c) possible
31	Electrical equipment	Electrical and mechanical	(a) Mechanical; (b) three electricians against 26 mechanics	Motors	Item (c)
32	All pumps	In handling belts	(a) Mechanical; (b) electrical 75% of mechanical cost	All machinery breakdowns and belt repairs	
33	Machine tools and drives	Mechanical	(a) Mechanical	Control, elevators, motors, conveyors, factory call and fire alarm systems	Item (a); also importance of carrying repair parts
34	Electrical and mechanical both neglected and abused	Machinery, shafting and pulleys	(a) Mechanical	Inspect all electrical equipment	
35	Lighting shamefully neglected	Control equipment on drives frequently started	(a) Mechanical department has 35 men; (b) electrical department has 5 men on maintenance	Control, elevators and lighting	Item (a)
36	Maintenance of protective devices	Inspection of electrical equipment	(a) and (b) about 50-50	Motors and lighting	Item (d) makes savings of (a), (b) and (c) possible
37	Electrical	Lubrication of bearings	(a) Mechanical 70%; (b) electrical 30%	Motors, elevators, conveyors	Item (d) and (c)
38	Automatic control	D. C. Motors	(a) Mechanical; (b) electrical equipment kept in better condition	Motors	Item (d)
39	Mechanical neglected — electrical abused	Mechanical	(a) and (b) about 50-50	Motors 50%; control 20%; elevators 5%; conveyors 10%; lighting 14%; factory call ½%; fire alarm ½%	Items (a) and (c)
40	Equipment used by several operators	Group drives	Mechanical	Motors in summer, motors and lighting in winter	Items (c), (a) and (d)

While the answers to the questions asked vary according to the character of mechanical and electrical equipment operated, they indicate in a very definite way the kind of thinking that is given to works maintenance from all standpoints. Answers to questions Nos. 1, 2, 3 and 4 are for the most part self explanatory. An interesting variation of opinion is shown, however, in the answers to question No. 5. Of the 40 replies, seventeen give first place to division (d) of question No. 5; ten to division (c); eight to division (a) and one to division (b). Also eleven replies mention combinations of divisions (a) and (d). The significance of these eleven replies is that they represent works where inspection and general maintenance work is well organized. The replies that give first place to division (c) are those where production is carried on in a progressive chain or on groups of equipment.

The following comments supplement the replies in the table and bring out some additional details of maintenance work.

James Foster, Electrical Superintendent, L. D. Leach & Company, Cairo, Ill., states that his company is engaged in the manufacture of oak flooring and lumber of interior finish dimensions. The electrical equipment consists of 60 motors with a connected horsepower of 1020 and a 150-kw., 220-volt, 60-cycle generator. The generator load is carried at unity power factor by driving a large fan on a dust collecting system with a 150-hp. synchronous motor. The average daily load of the plant is 3800 kw. hrs. and energy is purchased with an arrangement provided so that all feeders can use either source of power by manipulating double-throw switches.

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Mr. Foster says that his experience has indicated that the electrical end of factory equipment is more abused than any other, owing to the use of transient and common labor in operating machines. He believes that the maintenance man can show the greatest saving in the electrical department since delays in production caused by shutting down to change bearings or compensator parts is very expensive. When one unit is shut down from 15 to 20 men are idle. The largest amount of the maintenance man's time is taken in keeping dust and dirt from the motors, checking the oiling system and repairing compensators.

In reference to the question on saving shown by adequate inspection, maintenance and overhauling of plant equipment, Mr. Foster states that since production is essential in the plant, adequate inspection results in increased and continuous production. Constant vigilant inspection is maintained on all apparatus, consequently little defects are caught before they can develop into a cause for breakdown. All reports are investigated and repairs made on the night following the daily report. An adequate supply of bearings, coils and compensator parts is maintained at all times. The maintenance work is taken care of by the electrical superintendent, one electrician and one inspector.

F. G. Bonn, Chief Electrician, Hammond Cedar Company, Hammond, B. C., Canada, makes the following comments in addition to answering the maintenance questions referred to in the accompanying table:

"When I came to this lumber plant everything was steam driven. Now nine-tenths of the mill is motor-driven; in fact, everything but the head saw and log haul. Where we have gained is in room, as the many shafts and counter-shafts with belts and gears took up much space below the floor. The first installment cost has been quite high. It figured about $18 per horsepower, but considering the enormous saving on belts, oil and leather, we can say that the change soon paid for itself. Furthermore, we can run part of the plant without interfering with the other now.

"*Question No. 3*—The maintenance on mechanical equipment is still higher than the electrical equipment, but I believe it will soon run 50-50. I include in electrical equipment lights and alarms. The mechanical maintenance man has to spend a good deal of his time on conveyor-chain repair, but this has been considerably improved by putting all conveyor chains on one standard and by making the links in our own shop. We are using a chain with 10-in. pitch and 10-in. width throughout. About 50 per cent of the time of maintenance men is spent on motor troubles which are 70 per cent caused by bearing trouble, often through too tight belts. That is why we put in as many direct drives through flexible couplings as possible. About 40 per cent of the time is spent on compensators, as the points are often badly burned by incorrect starting. About 10 per cent is spent on lights and alarm equipment.

"I believe we save most through preventions of breakdowns and shutdowns by our regular inspections. Some parts, as carriages and some conveyor chains, are daily inspected; other parts weekly and some monthly. This also applies to the electrical equipment. For the electrical department I keep a record of all repair work with the time. From these records I have been able to tell how often I look at certain compensators. Motors with belt drives are inspected now every first week in the month. The belts are run off and the play in the bearings inspected.

"I might state further that the saw mill requires about 60 per cent, the planing mill 20 per cent, the shingle mill 15 per cent and the lath mill about 5 per cent of the electrical maintenance man's time. Mechanically, the saw mill requires 50 per cent, the shingle mill 30 per cent, the planing mill 10 per cent and the lath mill 10 per cent of the maintenance man's time."

H. L. Hayes, Chief Electrician, St. Croix Paper Company, Woodland, Maine, comments as follows in addition to answering the questions mentioned in the accompanying table.

"*Question No. 1*—Based on the resultant damage from a small amount of neglect, I think that electrical equipment is the most abused. For instance, a tight belt on a line shafting may burn out a bearing and the damage end there, but a tight belt in burning out a motor bearing may also burn out the complete motor winding.

"*Question No. 2*—In our plant the paper machines being direct producers should and do receive the greatest amount of maintenance. Lack of it would produce the greatest loss. Next comes the boiler room because neglect there means a direct loss in coal. Electrical equipment comes third because neglect may be more far reaching than ordinary mechanical neglect.

"*Question No. 3*—In our plant I think that inspection of the electrical equipment is more systematic, but it is not as expensive, and the maintenance is not as great as on the mechanical equipment. In general, taking power developed, the engines and miscellaneous mechanical equipment require and have a great deal more maintenance expense and attention than the electrical equipment.

"*Question No. 4*—In our plant the subjects receive the most attention in order listed: Motors—including cleaning; control equipment; lighting. The other subjects are of minor importance because we have a very small amount installed.

"In regard to question No. 5, I believe their importance is in the order listed below: No. c, first; No. a, second; No. d, third; No. b, fourth.

H. M. Cullen, Chief Engineer, International Paper Company, Turners Falls, Mass., states that no equipment is neglected more in the average plant than electrical apparatus. "In many installations the master mechanic or engineer in charge may have little knowledge of electrical operation and feel afraid to undertake repairs on motors and starters. The fact that many motors are running under these conditions today speaks well for the makers. Few maintenance men appreciate the necessity of keeping motors clean and consequently motors are allowed to run until the insulation breaks down.

"Motors should be systematically inspected, cleaned and the bearings kept filled with clean oil. The air gap should be tested at least once each month and the belts should be gone over each week. Care should be taken that oil does not find its way into the windings and lower parts of the stator in a.c. motors. Under such conditions it is impossible to blow out the dirt which accumulates there and the result is a breakdown of the insulation on the coils.

"Starting boxes and compensators should be inspected, since poor contact on one phase may cause the motor to run hot. The writer keeps a card index on file for each motor that shows all work done with the corresponding date. Each motor has its number painted in white figures on the frame and on the starting box. The compensator also carries a red arrow showing the direction of rotation.

"Once each week the rotors are taken out of motors and the windings thoroughly cleaned and given a coat of insulating varnish. Oil and dirt can cause more trouble with motors than all other things put together and a regular and thorough system of inspection will go a long way toward preventing breakdown."

K. L. Rose, Assistant Chief Electrician, Chevrolet Motor Company, Flint, Michigan, says: "From my point of view, electric motors receive about as much abuse as any equipment in industrial works. Where motors are carrying heavy overloads night and day there is an indication that something is radically wrong when they happen to stop. Yet the operators will often try to start them. If they will not start, the lever is frequently pulled back to the running side and left there. This is a kind of carelessness that must always be contended with. If maintenance men would show operators a few things about taking care of their machines, much could be accomplished in reducing troubles. Usually the machine operators know nothing at all about electrical equipment. It would be difficult for me to say whether the saving by inspection and general overhauling will be greater by preventing costly breakdowns or failures, but I believe that some knowledge of the equipment and thorough inspection will prevent both."

N. W. Coffey, Mechanical Engineer, Southwestern Cement Company, El Paso, Texas, states that in a cement

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mill the screw conveyors and pivot bucket carriers are neglected and abused more than any other equipment due to the fact that screw conveyors are always cased in to prevent the escape of dust. Pivot bucket conveyors cause less trouble, due to the fact they are open and in sight for inspection at any time. "In my estimation in this particular plant I would say the kilns are the most important part of the plant. The heat from the kilns is utilized in waste-heat boilers to furnish steam for the generation of electric power for the production of cement.

"It occurs to me, from an operating standpoint, that successful conveying and elevating devices are of most concern in the manufacturing of cement. It is true that we would have no need for the agents were it not for the quarry, the railroad transportation facilities, the crushers, dryer, raw grind, kilns, etc., however, it is precious little time we ever lose in our operations because of these machines, probably due to our efficient operators, or to the machines being made fool proof. In any event, we have run better than 95 per cent of a possible 100 per cent this season so far as department machines are concerned.

"I would not convey the idea that we have lost a great amount of time because of the elevation and conveying devices that we have in service for this would not be true. However, inasmuch as the cost of repairs for the elevation and conveying machines together with the labor cost necessary to keep the devices in repair is of such moment, I do not feel that there is any argument but that the handling of the material is of most concern.

"The exact figures in this instance are not available; however, from observation, I would say that of the repairs we have made this year, 50 per cent of the labor and material could justly be charged to elevation and conveying."

J. H. Gallant, Chief Electrician, Canada Cement Company, Belleville, Ontario, Canada, states: "From experience I believe that the electrical equipment in a manufacturing plant is most often neglected and abused, not wilfully as a rule, but through ignorance and misapprehension of what it really can or is intended to do.

"*Question No. 1*—In the electrical department especially the neglect and abuse is in the case of key motors, such as motors on elevators, conveyors, etc., which carry material in process to or from a department; also on motors with any system of remote control, push buttons, switches, etc.

"*Question No. 2*—In the mechanical department special attention to lineshafts for alignment and to bearings will always show results in increased production due to fewer and shorter interruptions.

"*Question No. 3*—In our plant the mechanical end requires more maintenance work than the electrical end, especially since we have changed the majority of our motors to ball bearings. I am satisfied that by changing all our motors to ball bearings that we will cut down our electrical maintenance work by over 60 per cent. For industrial plants in general, maintenance costs are higher on electrical than on mechanical equipment in proportion to the machinery employed.

"*Question No. 4*—In our plant the maintenance man's time is taken up mostly by the following in the order given: Conveyors, pebbling, relining and repairing grinding mills, elevators, motors, control equipment and lighting.

"*Question No. 5*—In my estimation the most important item in which a saving can be effected through proper inspection, maintenance and overhauling is No. (c), namely, "by increased production through keeping material or work in process constantly moving, with minimum shutdowns." The other three items seem to be subsidiary to this third one of "keep going." Regarding the first or saving through the prevention of costly breakdowns: If breakdowns are avoided the material will keep going and it is very seldom indeed that the costs of labor and materials for repairs on any breakdown come to anything near the loss due to the machinery being idle. The second, "the saving of spoiled materials through fewer interruptions of processes," naturally depends on this first mentioned third item. As for the fourth item, "the saving in the life of equipment and fewer failures through inspection," the only and ultimate end of proper inspection and maintaining machinery in good order, is this ideal of all industrial executives to "keep going."

"All inspection, however, will be more or less useless unless the inspectors' reports be acted on immediately after they are received and thus by timely repairs save costly breakdowns, costly especially through the machinery being idle while repairs are made, which, if attended to in time, could have been done in a fraction of the ultimate time required."

Paul Justus, Superintendent Electrical Department, Chandler Motor Car Company, Cleveland, Ohio, points out that machine tools are often neglected or abused in a large works owing to the fact that they are frequently purchased too small for the work they are to perform or are crowded beyond their cutting, drilling or planing capacity. Owing to the fact that a machine tool usually requires considerable more time to overhaul than a motor, the production department is slow in consenting to have it taken out of service. "Keep it going" is the usual watchword.

In reference to the maintenance of fire alarm systems, Mr. Justus states that owing to the extreme importance that this system shall function properly at the time when most needed, greater care is used in making the installation and hence it requires less upkeep than some other factory electrical systems. He considers the saving effected through prevention of breakdowns the most important item in general inspection, maintenance and overhauling of plant equipment combined with the carrying of sufficient repair parts to be able to quickly repair unforeseen breakdowns and natural wear and tear.

Otto L. Schendel, Electrician, S. Karpen & Brothers, Michigan City, Indiana, states that from his fourteen years of experience in the maintenance of mechanical and electrical equipment, the upkeep and repairs on machinery, shafting and pulleys is far greater than similar work on electrical equipment. The Michigan City plant of the company was formerly operated by steam, using a 250-hp. Corliss engine to run one half of the factory while the other half was operated by 25 motors on purchased power. Since January, 1922, an Allis-Chalmers steam turbine has been added and a large number of Crocker-Wheeler and General Electric motors. Most of the machinery is now operated by individual motor drives. At present 120 motors are in service, ranging in size from 1 to 50 hp., 440-volt, 60 cycles. A large turbine will be installed in 1923 to take care of service in the plant which is now operated on purchased power.

"Motors are given an inspection once a day. Every Saturday they are blown out, cleaned of oil and are tested for load, rotor clearance and bearing wear, which are the main points in keeping the equipment in good operating condition. Two maintenance men and their helpers take care of this work and besides wire hundreds of lamps which the firm manufactures.

Joseph F. Adams, Chief Electrician, International Harvester Company, Akron, Ohio, in answer to the question on equipment neglected or abused by an operating organization, calls attention to factory lighting. He states that not only is inadequate lighting provided as a rule but that which is provided is frequently forgotten and soon becomes very poor and inefficient.

He also refers to frequent abuse of control equipment, especially that used with motors that are started many times during the day where a group drive is provided.

A. E. Arnold, Electrical Engineer, Oakland Motor Car Company, Pontiac, Michigan, states: "I find the greatest neglect occurs in the maintenance of protective devices. Either the operating electrician fails to attach much importance to them or else he looks on them as a necessary evil. I believe, however, the former is the case. It seems that the conception of a protective device by the average electrician is that it requires no attention because it has been designed to operate automatically and will do so regardless of any other condition. I have seen relays in which the set screws have be-

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come loose and allowed the setting of the iron plunger to change considerably; also the small copper contacts which are usually incorporated into the design of a relay of the solenoid type have been allowed to oxidize to such an extent that the relay would be absolutely useless, due to the high resistance in the operating coil circuit.

With reference to fuses I find the same laxity exists. Fuse clips are not given the attention required. Also an overload may have occurred at some period in which the fuse failed to blow and consequently the clips have become heated and annealed, thus permitting the clips to lose their effective pressure on the ferrule of the fuse which would eventually injure the equipment it was protecting.

"In answer to the question: 'In what departments of the plant or on what equipment can inspectors and maintenance men show the greatest saving?' I infer that you mean the ultimate saving possible. In a plant that is entirely operated by electric motors, such as ours, I would say that the motor is the vital factor in determining the saving to be made. I believe that personal instruction on maintenance and inspection by the chief, followed up with a printed form containing a systematic routine method of inspection covering the motor in all the essential details and used as a general schedule for every-day use (the schedule of inspection to be continuous in operation) will show the greatest saving.

"In answer to Question 3, on a comparison of general maintenance of electrical equipment with that on mechanical equipment, in general I would say that there is about as much work in one division as there is in the other, this being based on the number of men required for each department during a production period. Motors and lighting require the largest amount of the maintenance man's time as a general rule.

"In reference to the saving which can be shown by adequate inspection, general maintenance and overhauling of plant equipment, both electrical and mechanical, I believe that saving in life of equipment and fewer failures through inspections makes possible the other three savings which are mentioned. As the continuous operation of a plant depends on the readiness to work of all the factors that go into producing the final product, it is easily seen that if all these factors are inspected and watched carefully there would be no costly breakdowns or spoiled material or the necessity of shutdowns occurring, to reduce the final output of the plant."

(*Continued from page* 31)

men, 1100 hp.; four men, 2000 hp., and five men, 6000 hp. As already stated, operating conditions will vary these numbers considerably.

Frequency of Inspections and Overhauling.—Once a week is the favorite time for making inspections. Thirty companies (out of sixty-two reporting) conduct weekly inspections on motors; seventeen companies daily, and six monthly. Forty-seven companies reported that they inspect control equipment. Twenty-three referred particularly to cranes and twenty-four to material-handling equipment. The inspection periods for all of these follow the same order as for other equipment; namely, daily, weekly and monthly.

namely, daily, weekly and monthly.

Thorough overhauling is done as it becomes necessary in 34 plants out of fifty-four reporting. Twenty-eight plants overhaul at regular intervals. The interval between overhauls is one year for eighteen plants and six months for four of them. Most of the plants have no specified time for overhauling and in many cases overhauling is being done continually, passing from one machine to the next, in rotation. In thirteen cases where overhauling is done at regular seasons, seven of the dates fall in December, January and February.

Amount of Maintenance Stock.—The average amount of wire kept in stock by fifty-one companies reporting is about 3,000 ft., mostly of No. 14 and No. 12 B. & S. gage. Eight of the plants keep one set of brushes per motor, and four plants keep one set only. Among twenty-one other plants the average number of brushes in stock is 35. About 88 lb. of babbitt is the average of thirty-seven plants, and 42 pounds of solder is the average in forty-two plants.

Eighteen of the plants reported that coil and slot insulation is kept on hand. The average amount is 50 lb. Plant No. 26 in the table keeps 50 lb. each of 1/16-in. leatheroid, 1/32-in. leatheroid and mica plate, and also 25 lb. of grade B oiled linen. Plant No. 44 keeps cotton tape, oiled linen, asbestos and slot paper. This, in general, is the kind of insulation carried by all the plants which do repair work. Plant No. 44 also carries one-third to one-half a set of coils for a few of the most important motors. Plant No. 54 keeps on hand $500 worth of insulation.

Lamp stocks are kept on the average, at about 50 per cent of the number of lamps installed. In all the plants there are about 116,000 lamps totaling 16,000,000 watts. The 60-watt size leads in number (29,055) and in wattage (1,743 kw.). In wattage the 200-watt size is next (1,500 kw.) and the 75-watt size is third (1,462 kw.). In numbers the 75-watt is second (19,675) and the 40-watt size is third (15,240).

For every hundred lamps installed there are 137 replacements per year. One paper mill, No. 50 in the table, has 360 per cent of lamp replacements per year. A fertilizer plant (No. 21) has 300 per cent; a plant for leather boots (No. 43), 250 per cent; a valve plant (No. 33), 220 per cent, and a cement plant (No. 7), 200 per cent.

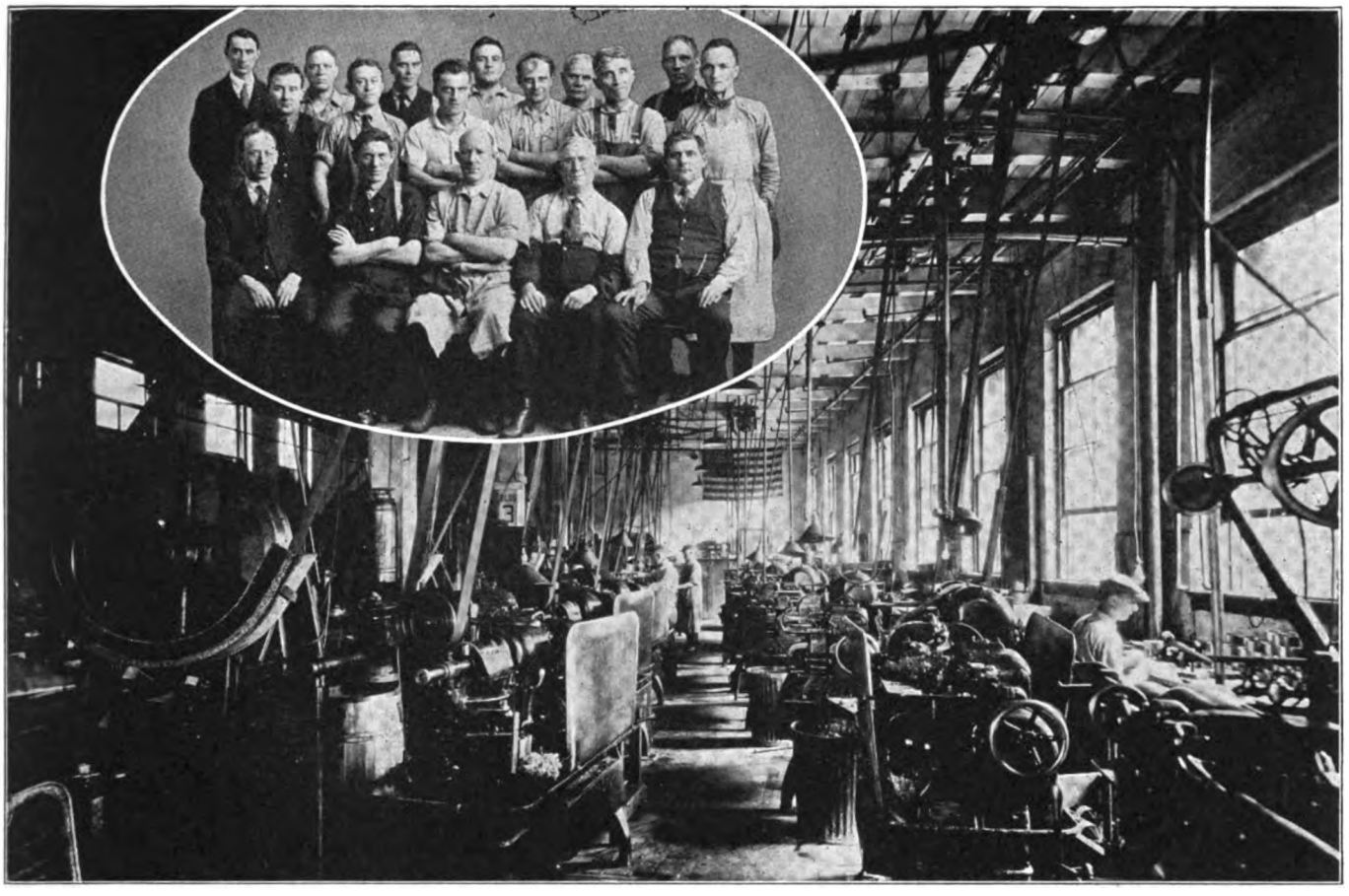
It has been noted that the plants making electrical equipment did not list much maintenance stock. These plants have material on hand for manufacturing purposes and do not have a separate storeroom for the maintenance department.

Responsibility for Maintenance, Production and Non-Interruption.—An interesting part of the table is found in the last two columns referring to the responsibility for maintenance, production and non-interruption of service. In thirty cases out of sixty reporting, the same man is in charge of all three divisions of plant service. In only four cases the man who has charge of maintenance and non-interruption of service, is not responsible for production.

The men in charge of maintenance in the different plants have twenty-two different titles and there are six who have no title at all. Of all these men, eight are superintendents; nine, master mechanics; four, electricians; three, engineers; six, no title.

There are 23 plants out of 53 reporting on productions where the man in charge of maintenance does not have charge of non-interruption and production. The men who have charge of this work has collectively eight titles. There are seven superintendents in this group and one each of seven other titles and one without a title. The titles of superintendent, master mechanic and works manager occur both in this group and in the group of men who have more direct charge of maintenance.

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This group of men has a record of 29 months without a lost-time accident among these surroundings where one would hardly expect such a record.

Underlying Influences Which Contributed Toward

29 Months Without a Lost-Time Accident

In One Department and a Similar 14-Months' Record for the Entire Works

By WILBUR WOODAMS,
Safety Engineer and Employment Manager, Hawk-Eye Works, Eastman Kodak Company, Rochester, N. Y.

CAN A factory with the usual complement of hazards achieve a record of one whole year without a lost-time accident? It can, and here follows the account of how it was accomplished.

In discussing this achievement for the INDUSTRIAL ENGINEER it would be most fortunate if a complete outlay of mechanical safeguards could be pictured and offered as the cause of a record which is at least unusual. The description of what has occurred would then be comparatively simple, and a duplication of the record easily brought about if the installation of mechanical prevention would duplicate the trick. It is true that little which seemed of value in the line of guards and mechanical aids to accident prevention was omitted, and the effort expended in this line did much to achieve the results attained. However, it is in the individual within the plant, and his use of the tools with which he works, that the true reason for accidents or their absence must be found. To the attitude of the whole force—the *collective individual*—call it plant spirit, plant pride or whatnot—the record of the Hawk-Eye Works of the Eastman Kodak Company must be credited.

This division is a small plant manufacturing a large variety of products, all of which fall in the general class of photographic accessories. The machinery consists of a wide variety of metal, woodworking and optical machinery, with the addition of a number of special machines. During the fourteen no-accident months, which extended from June, 1921, to August, 1922, the average number of employes on the pay roll was slightly in excess of four hundred. It would, perhaps, not be unduly pessimistic to suppose that even so moderate a number of people, spending 8¾ hours of each working day in any active capacity, in a five-story plant, would come to some mishap, even without the additional hazard of machinery. Yet a force consisting of approximately two-thirds men and one-third women avoided even the tumbles on the stairs, the infections, the slipping and the hazards of falling materials.

It is not to be expected that

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scratches and near accidents did not occur. In making this record a lost-time accident was considered as one which caused loss of time in a day other than the day on which it occurred. This is the same as a "reportable" accident as required by the New York Industrial Commission.

For several years ending with 1920, we had been paying an annual toll of approximately twenty accidents. The work was well guarded and every reasonable precaution taken but seemingly without effect. Apparently we had reached an irreducible minimum. Then came the business depression and the reduction to the point where the force was made up largely of long-service employes. Such a condition reacted immediately to reduce accidents to a very low point. Experienced workmen and long term employes are generally safe. With the accident rate at this low point in the spring of 1921 we began definitely to study the possibility of lengthening the interval between accidents with no goal set beyond the immediate present. The only object was to pass each successive day with a clean record. Interest increased as time went on until the effort to continue the record became a part of the consciousness of the whole force. Success succeeded. The spirit, the zest of the game, became its own motive power. Then gradually there grew a pride in the achievement in which each individual had his share.

The experience of one department at Hawk-Eye, in which is crowded a miscellaneous lot of manufacturing, offers a good example of the value and growth of this pride. The work in this department requires the use of a variety of metal working machinery, including some 20 presses used in blanking and forming jobs, draw presses, mills and drills, automatic and hand screw machines, square shears and lathes besides a large number of bench forming operations and soldering jobs. The work of the department was done on the bonus system with speed and production at a premium. Accidents were not unexpected here.

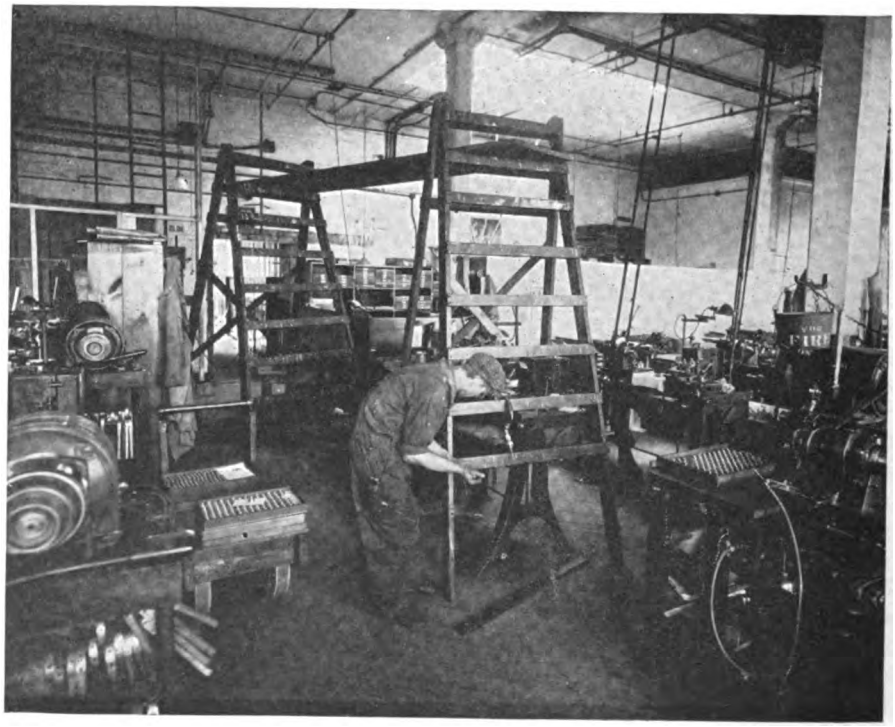
The change in the attitude of the department came gradually. The first no-accident month occasioned little interest; it had happened before frequently. The second caused some curiosity. After three months without an accident these men began to realize that they were making a splendid record. They began to take a lively interest in the addition of each successive day to their record. Men who apparently had never been conscious of accident prevention efforts began to say, "another day without an accident," or "another week and still going." The end of each month added to the record became the occasion for celebration. Their success was to them a real accomplishment; it was *theirs*, and *they* were making it.

The work of the department has always been well guarded. There was no change in methods. The difference was due solely to the changed attitude and the pride of accomplishment on the part of the operators. Needless to say we have first-class foremanship in that department with the foreman at all times the real leader of his men. It is twenty-nine months since the last lost-time injury to one of his employes and the record is still growing. There is no safeguard like the pride of accomplishment. We do not belittle mechanical safeguards, but it seems evident that they are but a part of real accident prevention.

MR. WOODAMS makes the following significant statement: "Any safety campaign will stand or fall according to the measure of co-operation secured from the Maintenance and Construction Department..... Incidentally there is no single group which can so successfully combat the hazards which continually occur when least expected throughout the plant. Watchfulness and real interest on their part has an immeasurable value in any safety campaign while carelessness is certain to end in disaster, either for themselves or for some fellow workman. When they are on the job safety begins with the machine. When these men become safety workers much of the routine of accident prevention is eliminated."

The Maintenance Department's Place in a Safety Campaign

Any safety campaign will stand or fall according to the measure of co-operation secured from the *Maintenance and Construction Department.* Scattered about the plant, often without direct supervision, moving heavy objects, salvaging, oiling and performing all the kindred occupations which go to make up the daily tasks of maintenance men, they are quite generally unguarded except by their own care. Their work is a danger point in any safety cam-



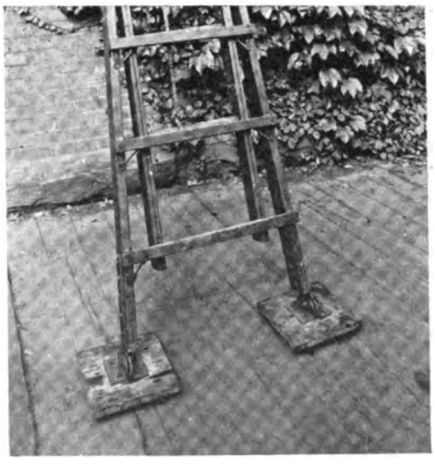
Maintenance men do much of their work alone with little direct supervision.
For this reason they must be convinced of the necessity of thinking safety. This man is removing rungs from the horse so that it will fit over the lathe. Will he remember when he comes down?

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paign. Incidentally there is no single group which can so successfully combat the hazards which continually occur when least expected throughout the plant. Watchfulness and real interest on their part has an immeasurable value in any safety campaign. Carelessness on the part of maintenance men is certain to end in disaster, either for themselves or for some fellow workman. When they are on the job, safety begins with the machine. When these men become safety workers, much of the routine of accident prevention is eliminated.

We did not realize the importance or value of the *Maintenance and Construction Department* before our no-accident year as thoroughly as we do now. During that period we began to check the maintenance men more closely and to learn the possibilities for service that exist in their work. The attention which was focused on them, and the success which met their efforts aroused in them a loyalty to the cause which had previously been a useful force lying dormant. Here again, however, the question of foremanship was paramount. The foreman not only grasped the idea himself but got it across to his men successfully.

For some time we had conducted our safety work on a basis of departmental competition. We found that in discarding this method we were able to replace it with a combined effort to make the whole plant safe. It was at this point that the work of the *Maintenance Department* was invaluable. The idea was given to them through their foreman and through individual talks with the men of the department. A "progress report," reproduced on page 40, submitted monthly by the foreman which detailed the accident prevention work done by the department, was, and still is, a source of inspiration. It does not hinder in the least to let them know that their work in this regard is watched.



This extension ladder will not slip.

Coco-matting is fastened on the bottom of these boards hinged to the foot of the ladder. It can be placed in practically any position. This accident-prevention idea evolved from a suggestion made by one of the men. The principal factor in safety work is to get the men to think "Safety." They will then be careful and make suggestions which may be of much value in furthering accident-prevention work.

It would be extremely difficult to select any single prominent incident in which our *Maintenance Department* has aided in reducing accidents, as each incident in itself is commonplace. It is only the composite which seems unusual. One example, although of little importance alone, shows the spirit and the effect of these suggestions. One of the men in the *Maintenance Department* made a simple little suggestion for an improvement on the guards which already covered the gears of some milling machines. It seemed to be a refinement but was approved for the potential value in the adoption of the man's suggestion. Some months later an inexperienced operator dropped a small lug which he was milling. The piece fell through the machine, landed on the gear guard and the operator tried to rescue it with his finger. The addition to the guard which had been suggested by the maintenance man prevented the operator's hand being drawn into the gears and let him off with only the loss of a small amount of skin from the end of his finger.

The greatest hazards in the work of our *Maintenance Department* seem to have been from falling materials and slipping ladders. The last named hazard has been effectively overcome by the use of coco matting feet on the ladders, a suggestion made by an employe of the Kodak Park Works. They have been in use for something over a year and so far have functioned perfectly. The hazards of falling materials, faulty tools and equipment, as well as the many other dangers to which maintenance men are exposed can only be eliminated by care and foresight on the part of the men themselves. There is no other preventive. The best, and therefore most difficult, factor of safety work is that which teaches and inspires care and foresight. First we tried to merit the co-operation of the men of this department, then to give them credit for the results of their efforts.

The attainment of this co-operative attitude on the part of the employes of any company depends directly upon its labor policy. Therefore, management must merit co-operation in the safety movement by its attitude toward *all* questions in-



He forgot that he had taken the rungs off.

In this case the maintenance man put himself in danger. Often, however, his carelessness endangers others, since by leaving heavy objects overhead or debris on the floor as a tripping hazard, or through neglect to replace guards. He is in an excellent position to see hazards and will suggest methods of removing them if he receives recognition and encouragement.

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Eastman Kodak Company
Industrial Relations Department
Accident Prevention Branch

Progress Report for Month of November 1922

Division Hawk-Eye Works.

Date	Only completed items will be reported	Remarks
	Conference or Committee Meetings	
Nov. 7	Meeting of Plant Safety Committee	
" 28	Meeting of Executive Safety Committee at O. of C.	
	Inspections	
Nov.14	Routine - Plant Safety Committee (Special Inspection Com.)	
	Fire Drills	
Nov.9	Bldg.# 3	
" 5	" # 6	

Date	Only completed items will be reported	Remarks
	Guards installed or altered, or conditions remedied	
Nov. 1	Made and installed guards for machine #229, 2nd.floor,Bldg.5	
" 1	Made and installed motor guard, machine #1438	
" 2	Repaired floor, Bldg.5,1st.floor, cementing holes in floor,etc.	
" 2	Made and installed gear guards on bench lathe in Instrument Dept.	
" 2	Made and installed motor guard on machine # 3249	
" 5	Changed belt guards on Boring machine #229 in Mill Dept.	
" 5	Made and installed oil drip pans on shafting, 3rd. floor,Bldg.5	
" 11	Made and installed gear guard on machine # 75 in Brass Dept.	
" 15	Installed oil drip pans on motor # 92, 2nd. floor, Bldg.1	
" 16	Made and installed guards on press# 114 in Press Dept.	
" 18	Made and installed guards on press # 3252 in Press Dept.	
" 22	Made and installed belt guard on emery wheel # 59 in Brass Dept.	

Wilbur Woodams
Safety Inspector

"Progress Report" on which safety work completed during the month is reported.

It is encouraging to see what has been accomplished each month. This progress report also gives credit for work completed. It is made by the safety engineer to the general safety supervisor of the company. The reverse side of this report, shown above, carries the list of work done which the foreman of the Maintenance Departments sends in monthly. No printed form is used for his report; it is simply an enumeration of the items covered.

volving employe relations. It should not seem boastful in the light of the record made, to say that co-operation has been obtained at Hawk-Eye, at least in the field of accident prevention. Our safety organization begins with the management of the company.

How Safety Work Is Organized

Within the plant we are organized simply with a safety committee representative of each department and headed by a chairman appointed by the management. The departmental representatives are appointed by the foremen as their selection in this way has been found to achieve greater co-operation within the department than the former method of appointment by the committee chairman. Departmental representatives are chosen semi-annually, and are rotated as far as possible in order to give the experience to as many people as possible. In addition to the regular representatives, a few others who have proved their interest and value to such an extent, are considered more or less permanent members of the committee.

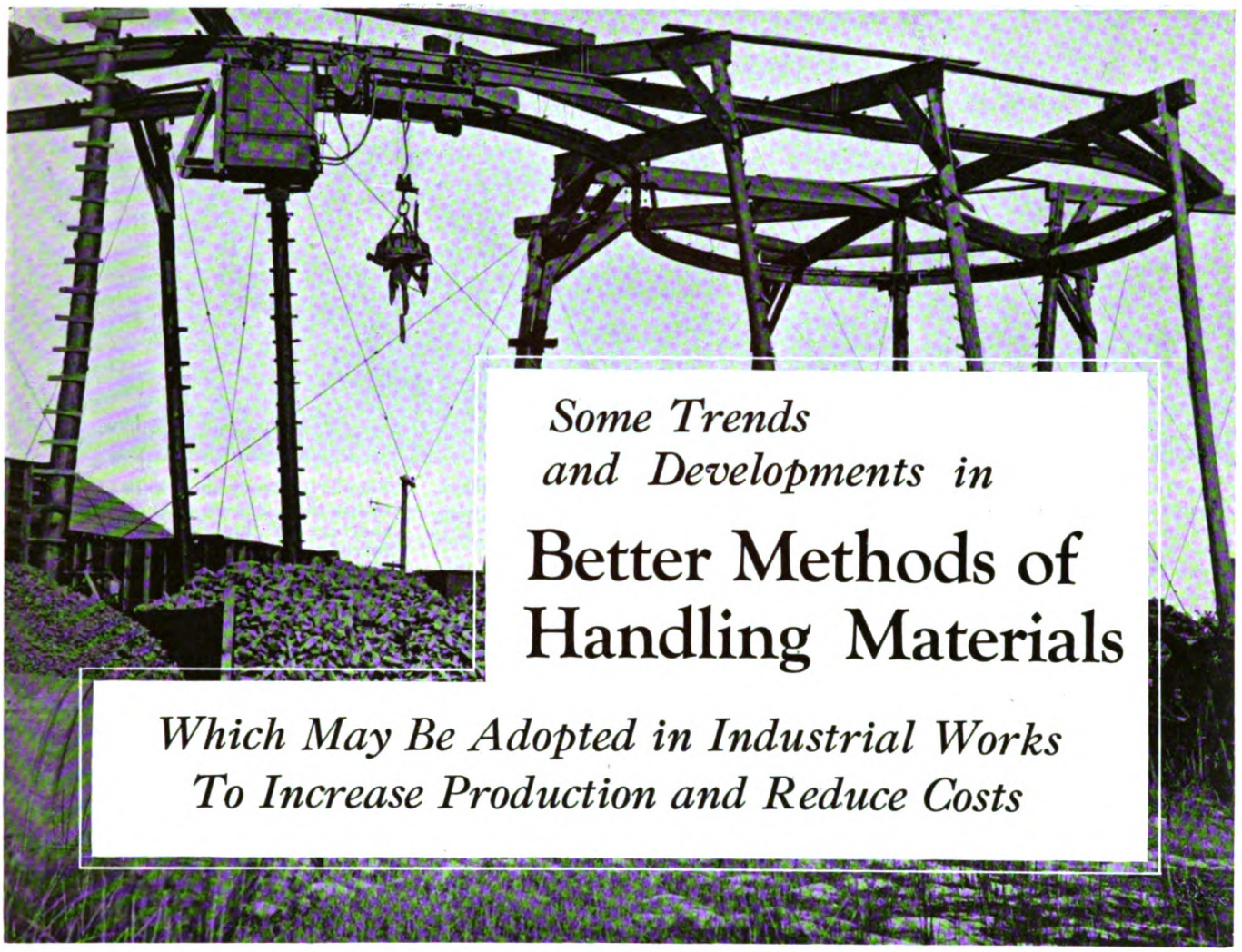
Meetings are held monthly for the discussion of suggestions and progress made since the last meeting. The chairman appoints a sub-committee of three each month which makes a complete inspection of the plant and reports in writing at the next meeting. These are submitted to the superintendent for disposal. The work of the plant safety committee has been, throughout, an important factor in making the work of real interest to the employes rather than an effort imposed by the management.

The part played by propaganda in the success we have had is of course difficult to estimate. Persistence in this regard combined with an effort to put forth the best available undoubtedly contributed in good measure to the result. Any form of propaganda, be it bulletins, charts, signs, object lessons or whatnot defeats its own purpose if it is allowed to become stale and worn. It must be handled so that it attracts attention or it is valueless. We found that after a siege of safety propaganda a favorable reaction resulted from a temporary total eclipse of advertising effort. We omitted the sensational, the gruesome, and tried to maintain a serious tone. Education should be the foundation of all safety propaganda but it must be interesting and sincere to be effective.

Our plant dispensary, or hospital, as we call it, has been a contributor to our accident prevention work. The treatment the operator received in the hospital made it possible to send the man there with the slight cut for treatment without resentment. Our employes have been taught that it is not a sign of weakness to have even the smallest abrasion cared for by the nurse. The important fact is that they did come, and while there is no way of estimating the number of infections prevented in this way, it does not seem extravagant to say that we would not have had a no-accident year without such free access to and use of the hospital.

If there is any single lesson to be drawn from the results attained at the Hawk-Eye Works, it is that safety work in itself is but one unit in the whole picture. The best of accident prevention work cannot succeed by itself alone. It cannot achieve the results desired without that co-operation which comes only when merited in every phase of the contact between management and its men. Nor is it necessary that management surrender its prerogatives to secure co-operation. If the men are satisfied that they are led by competent men they will not desire to usurp their power.

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Some Trends and Developments in

Better Methods of Handling Materials

Which May Be Adopted in Industrial Works To Increase Production and Reduce Costs

One man in an inclosed cab can operate this magnet or grab bucket in any kind of weather for handling pig iron, scrap, coke, or similar materials.

By FRANK E. GOODING
Associate Editor, Industrial Engineer

UNTIL RECENTLY, but little attention has been paid to careful analysis and standardization of the best methods of handling materials in industrial plants. Some attention had, of course, been given to improvements in certain operations and processes of the work, but these were not developed in such a way that they fit together. Too often the addition of a hoist, conveyor or an electric truck was considered a solution of the problem when it solved only part of it, yet big economies have resulted from such installations.

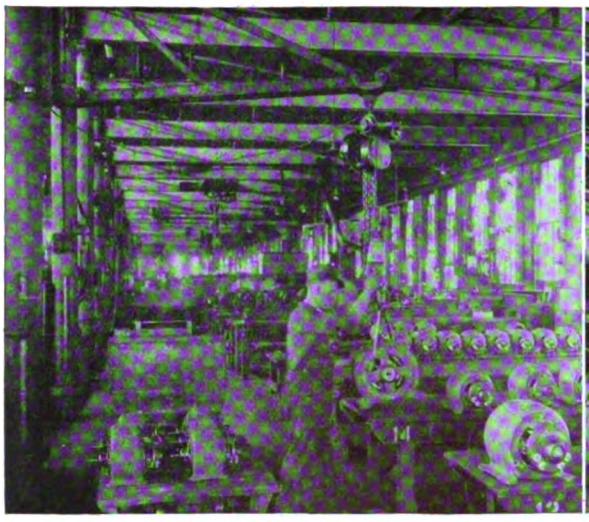
When it is considered that a large percentage of all industrial operations or processes are handling operations—picking up, laying down, or moving—the importance of the best methods of doing this work may be better realized. For example, a year or two ago the chief engineer of Deere & Company, Moline, Ill., showed by a careful analysis that it was necessary to handle—actually pick up and move—168 tons of material for each ton of finished castings produced from his foundry. A check in many other similar works would show that the pig, scrap, coke, limestone, cores and molding sand, patterns, flasks, debris, castings and miscellaneous other materials are handled many more times than were indicated in this check. These necessary handlings may be performed by hand, by mechanical or electrical equipment, or by combinations of hand and equipment.

The big savings lie in choosing the proper combinations and in making the best use of them. For example, wheelbarrows, hand loaded, may be satisfactory for moving pig iron in one plant while in another a combination of cranes, hoists, magnets and electric trucks or tractors are required. Where several men are employed most of their time on any handling operation, however, the economies in the use of equipment to do their work is worth investigating. Many material-handling installations have paid for themselves in less than a year and some within a few months.

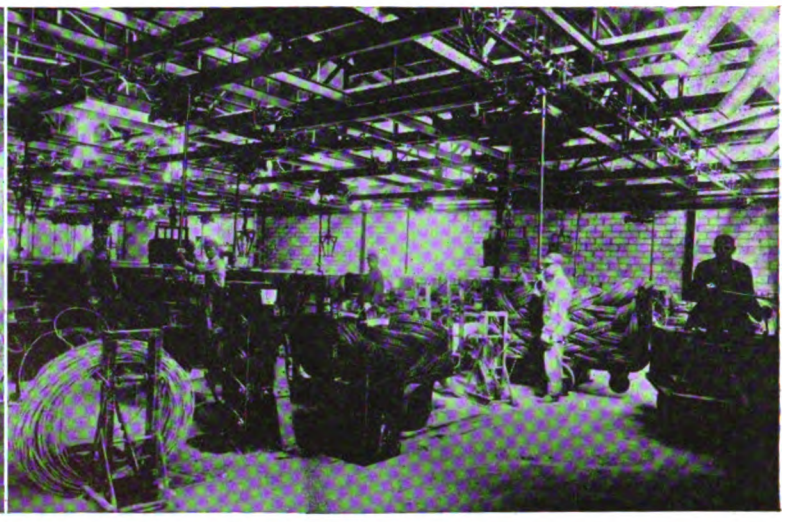
Why More Attention Is Given to Better Material-Handling Methods

Within the last few years much attention has been paid to individual industrial processes and changes adopted or new methods installed that would show a reduction of costs or an increase in production per man hour or per dollar expended. Under former methods of cost keeping, the material-handling expense was usually lumped under the heading of "indirect labor" or "overhead." In getting a closer analysis of costs, this general term "indirect labor" has been subdivided until now, for analytical purposes, in many instances the management knows which items go to make up this expense and about how much each costs. Such analyses have thrown the spotlight on ma-

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The tendency to electrify existing equipment is well shown in this special motor attachment for making a power hoist from standard hand equipment.



Formerly strong men were required to lift these 300-lb. rolls of wire. A shortage of this type of men has forced the installation of these electric hoists, operated by push buttons, so that a smaller man can now do the job much more quickly.

terial-handling costs. However, even these do not disclose all material-handling costs, as many are still covered up as a part of another operation. In this connection, time and motion studies have done much to separate the parts of work which are really handling operations from those which are manufacturing or machine operations.

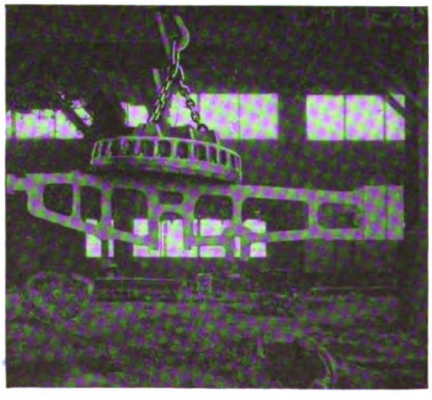
Probably the most important factor, however, in forcing attention to better material-handling methods has been a decrease in the number of rough laborers available. This is particularly true of what were commonly known in industry as "strong back" jobs. As a result, particularly during the past year, many mechanical devices have been installed in plants which have either eliminated this rough, heavy labor or make it possible for this work to be done at a minimum of physical effort. For example, one of the first places which felt the shortage of this rough labor was in the miscellaneous yard jobs, such as storing coal, handling pig iron, foundry sand or debris, or other similar moving jobs which required a considerable number of men at the same task.

These methods adopted are not new by any means; conditions have simply been favorable to a wider application of such equipment as locomotive, bridge or mono-rail cranes with magnets or grab buckets. Often these cranes and hoists are used in connection with trucks, belt conveyors, or other types of carriers, for the reason that many times the cranes cannot carry the material economically to its final destination. The big saving resulting from the use of a crane, however, is that it picks up tons at a time with only the expenditure of one man's time, whereas men pick up by the shovelful or by the piece. Also, the crane or conveyor can carry a continuous load of tons in the same length of time that one man can carry possibly 200 to 400 lb. at a trip. A large crane or belt conveyor and one man with a wheelbarrow are extremes in output.

An incidental saving as a result of using heavier equipment is the elimination of the expense incidental to the replacement and repairs of shovels, wheelbarrows and other similar equipment which are necessary for the men. This saving, in many cases, amounts to thousands of dollars in addition to the other thousands saved in the wages of each man replaced.

Small Installations Can Make Big Savings

It is not necessary that the installation be large nor cost thousands of dollars to be economically used. Even where only a few carloads of material is handled irregularly, many kinds of portable handling equipment may be used, such as portable belt unloaders, wagon or truck loaders and electric storage battery trucks with special bodies to haul a ton or more at a time instead of wheelbarrow loads.



One of the advantages of using magnets to pick up work is that it is not necessary to call a gang of men nor "fuss" with chains.

Conveyors of belt, apron, bucket and gravity types have played a very prominent part in the reduction of material-handling costs. In one New England factory a system of belt conveyors and pneumatic tubes, costing approximately $75,000, has doubled the output with a reduction of 72 operators and made a saving in labor of approximately $72,000 at an operating cost of approximately $4,000 a year. In any plant where men are continually walking back and forth at their work, a study of the advantages and possibilities of a conveyor for carrying the work between these two points will usually be found profitable.

Conveyors are used not only in moving materials, but also in progressive assemblies and to a large extent recently for temporary storage floors. Conveyors from machine to machine are in one sense a storage conveyor as well as a carrying conveyor. A good example of the use of conveyors for production and for storage was given in INDUSTRIAL ENGINEER, on page 504 of the October issue.

The savings which may be made through material-handling equip-

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ment in various combinations are so great that many companies are designing special equipment for their particular problems. Oftentimes this is but a slight variation of existing equipment but enough, however, to require special designs for the installation. Some of the examples illustrating this article show these adaptations of material-handling equipment for special cases that later have been found to be of wide enough use to become a standard type.

Lifting Light Loads Mechanically

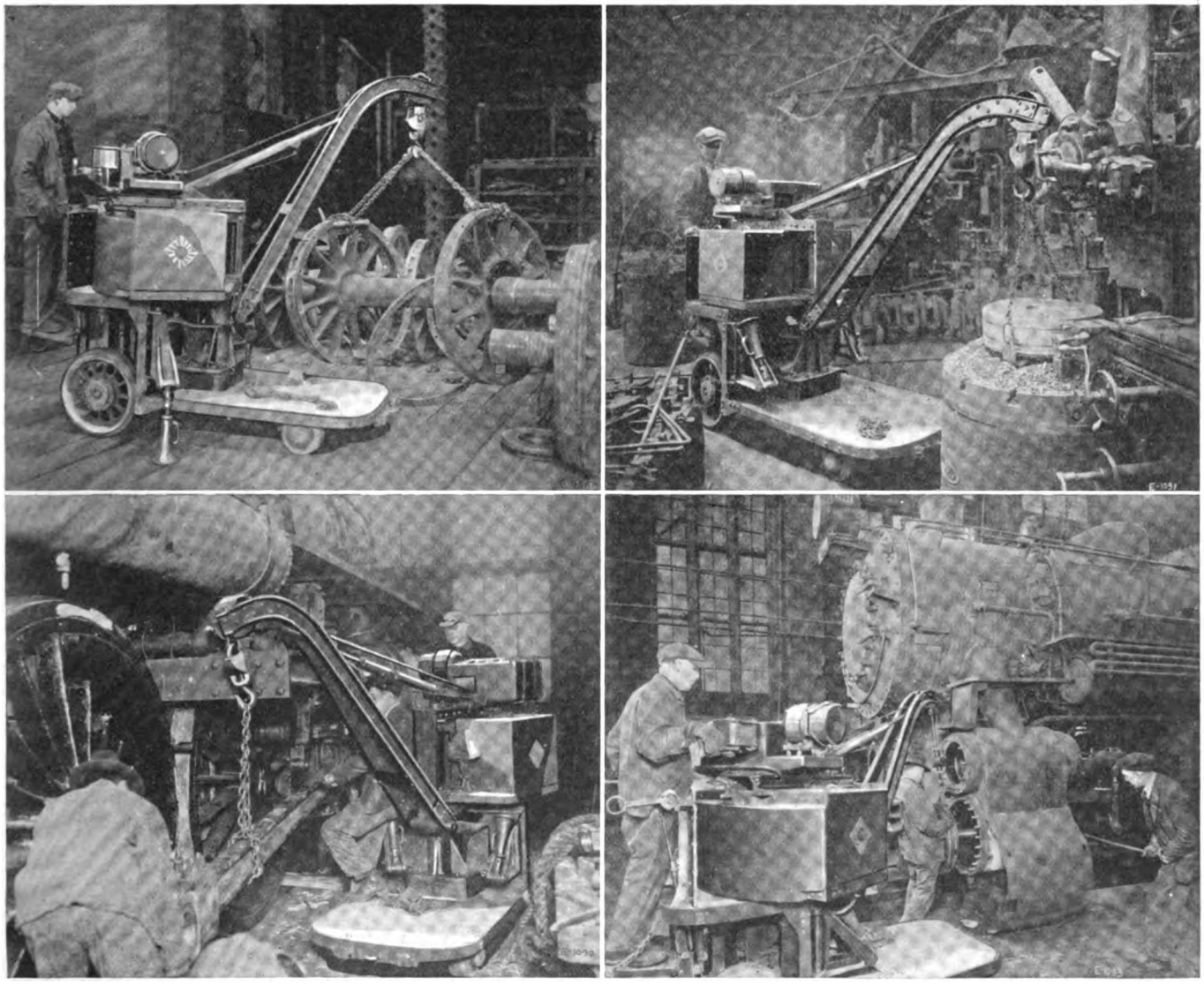
Another feature which has helped to increase and speed up production, as well as eliminate the number of men required, is the addition of numerous small hoisting units in a shop to supplement the large overhead traveling crane. In many plants where one large traveling crane had been installed large enough to take care of a wide range of work, it spends most of its time on light jobs. An auxiliary installation of small hoists to serve machines leaves the heavier and more powerful equipment for the heavy work which it alone can do.

The wide demand for equipment for this purpose has led to the electrification of three types of light machines. Several electric hoist manufacturers have developed light electric hoists of approximately ½ to 1 ton capacity to take their power from an extension cord.

Similarly the Economy Engineering Company, Chicago, has recently electrified many installations of its small portable elevators up to 1,500 lb. rating where they had been sold for hand operation. These also take power from a socket. Another company, The Motorbloc Corporation, Philadelphia, Pa., has designed a special electrical motor attachment to be placed on standard hand-operated hoists to electrify them. This is controlled from a push lever mechanism held in the hand and receives power from an extension cord. Numerous other similar applications of material-handling equipment which add to their flexibility have been designed recently in response to the demand for increasing production, eliminating extra labor and reducing costs.

One Method of Increasing Speed

Many overhead cranes designed during the past year have been for high-speed operation. One crane user, A. L. Gear, chief electrician of the Gary Screw and Bolt Company, Gary, Indiana, has re-designed his equipment to get not only a higher speed but operation at two speeds. Mr. Gear realized that while a crane was designed for handling its rated load, only seldom was the actual load ever up to anywhere near its maximum rating. By dividing and reconnecting the fields of the direct current hoist motors, the crane was speeded up for handling the light loads which comprise the larger percentage of the work. Through special connections in the



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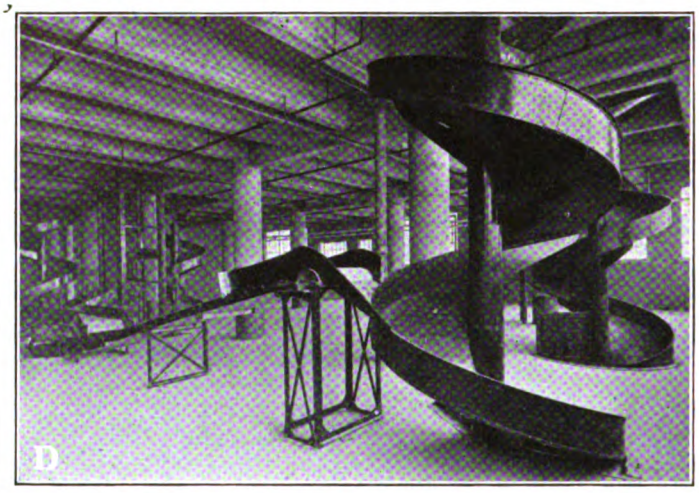
Nine Material-Handling Operations

Showing Ways Work Has Been Speeded Up at Lower Cost

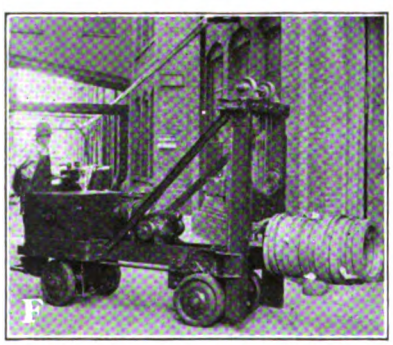

A


B


C


D


E


F

A—If these Link-Belt portable belt conveyors earn their way handling coal in Japan, where labor is cheap, what might they do here?

B—Big gantry cranes like this Meade-Morrison installation take the place of hundreds of men.

C—This Cowan electric lift truck speeds the "peddling" of supplies at a low labor cost.

D—Alvey-Ferguson spiral chutes, belt and vertical conveyors supplant trucking in this flour mill.

E—This McKinney-Harrington portable conveyor handles supplies to and from a balcony storeroom.

F—Rolls of metal strips are handled to and from annealing furnaces by this Baker R & L special tiering truck.

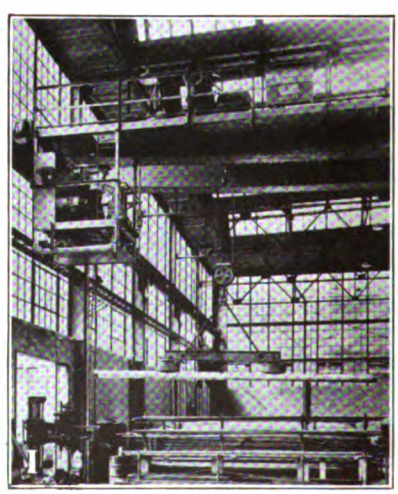
G—The strength of a man is multiplied many times by this Shepard hoist.

H—A modification of the electric lift truck (Elwell-Parker) handles crucibles to and from an annealing furnace.

I—One floorman and the crane operator "pick" stock in this steel warehouse with this Ohio Electric crane and magnet. The two men supplant a gang.


G


H


I

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cab the crane man can operate the crane either at its designed speed or at the increased speed by simply throwing switches. Light loads are now hoisted at double speed. This has resulted in increasing the capacity of the crane by about 40 per cent. This crane is used for loading scrap with a magnet and for unloading steel rods and bars from cars. This one crane was re-designed as an experiment. Mr. Gear believes that for general operating practice it would probably be better to increase the speed of this motor only about 25 to 35 per cent instead of 50 per cent. The bridge and trolley motors were not changed.

Light Lift-and-Carry Equipment

For certain lines of work, combination or two-operation (lift and carry) equipment has established a firm place in industrial works. Perhaps the most common examples of this type are the hand and electric elevating-platform trucks. These are so common as to hardly need description. But few users realize, however, their wide application. Wherever material must be moved over varying routes or when handled intermittently in moderate quantities, it always pays to investigate the applicability of either hand or power elevating platform trucks or a combination of the two with possibly tractors and trailers if the material is hauled any distance. Very large quantities handled over a definite route usually are more economically handled by permanent equipment such as conveyors or cranes.

The most important feature in increasing the use of lift-and-carry equipment is in providing suitable types of skids or platforms. For example, carefully machined parts which might be damaged if permitted to come in contact with each other are easily protected by placing them on a special skid designed to separate each part. For example, one large automobile company saved thousands of dollars in one year by the use of these special skids over the former practice of throwing these parts into tote boxes. For example, a machined crankshaft represents considerable time and labor and can easily be damaged by being piled in promiscuously with other crankshafts. The saving of only a few crankshafts would soon pay for the extra expense of making the special skids for handling this work. Literally hundreds of special designs for skids have been made for the solution of particular problems in various industrial plants. Some have and others will be illustrated frequently in the "Handling Materials" department of the INDUSTRIAL ENGINEER.

At first skids were plain, homemade wooden frames. Now the tendency is to use a much heavier and more substantially built platform with steel or iron supports or legs bolted securely to the platform. Practically all elevating-platform truck manufacturers supply substantial skids of this type "knocked down" for shipment. The use of pressed steel skids is also increasing. While these were originally used for handling hot forgings, they are now quite commonly used for any heavy, rough materials such as castings or machine parts which are not damaged through contact with each other and are very abrasive to the wooden platform.

Tiering or piling trucks, which lift their load several feet instead of a few inches, and carry as well, are a development of the electric lift platform truck and the portable elevator or tiering machine. These are now used quite extensively for picking up material and piling it to the ceiling, several layers high by not more than one man and the operator, where formerly a large gang of men were required to do the same work. Some printing concerns are using these machines to pile box or roll paper to the ceiling and also to pile two or more skids loaded with printed and folded sheets on top of each other and so economize in storage space. One concern, instead of piling, suspends the upper, loaded skid from the ceiling. Instead of tiering trucks, portable elevators are very often used in combination with either hand or power lift trucks.

Cranes on Trucks as a Shop Tool

Although electric trucks with a crane hoist built on the platform have been on the market for a number of years, their application has increased within the last year. These have a wide application and in many plants they are considered one of the shop tools, as they are used to load small machine tools, to lift equipment and other parts when they are handled by the Maintenance Department, to set and remove dies, to pile material in the yard, to load and unload heavy castings or incoming material onto either industrial trucks or motor trucks, and many similar tasks. Railroad shops are using these to particularly good advantage, for example, in such jobs as removing cylinder heads, connecting rods and other pieces which are far too heavy to be handled by any less than two or three men. Without some such arrangement as this it would be necessary to rig up a chain hoist for each of these operations. The storage-battery truck with a crane can pick these parts up anywhere and carry them to the shop or to the locomotive, or assist in this (*Continued on page 47*)



Installations are more flexible if they are designed so that they can be used in connection with any equipment. This lift truck platform skid has wheels so that it may be moved by hand; chains enable it to be lifted by the shop crane.

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Kinds of Dirt Encountered When

Cleaning Lamps and Reflectors

In Works of Various Industries and How They Can Be Most EffectivelyRemoved

By N. T. GORDON

Experimental Engineering Laboratory, National Lamp Works of General Electric Co.



Plenty of soap and water is usually sufficient but, for oil and grease, Bon Ami, Old Dutch or Babbitt's Cleansers will speed up the job.

LIGHTING men know that the amount of illumination obtained from lighting equipment decreases gradually but surely with length of service, due to the dust and dirt which accumulate on the surfaces of the lamp and the reflector. A few months ago an investigation was undertaken to classify the kinds of dirt which may be expected to accumulate on the lamps in representative industries and to determine just how much the light output of lamps may be increased by cleaning them.

To determine the kinds of dirt to be found on lamps in regular use in the various industries, several companies were visited and from one to three lamps taken from each. The companies visited were representative of the automobile, paint and varnish, chemical and storage battery industries, machine shops, foundries, transportation offices and warehouses. In general, lamps were selected which had accumulated dust and dirt typical of each industry.

The total number of lamps used by these companies is approximately 16,000, about 85 per cent of which are clear lamps. Of the companies visited, 60 per cent do not clean their lamps at all, 33 per cent clean them at infrequent intervals and about 7 per cent clean lamps frequently at regular intervals. It should be borne in mind that this survey was made at a time of financial stringency, when many of the companies were operating only three or four days a week, with reduced forces. Maintenance men whose duties include regular cleaning of the lighting installations had been temporarily released and a much higher percentage of companies which clean lamps frequently can be expected when these men return to work under normal manufacturing conditions. Typical cleaning materials found in use at the companies visited were soap and water, Gold Dust and Oakite.

Tables I and II show the kinds of dirt found in twenty-four different service locations and the foot-candle measurements, taken from a fixed position, before and after cleaning the lamps. All but two were clear lamps; these two were bowl-frosted lamps.

It will be seen from the two tables that four separate classes of dirt were encountered; namely, dust and dry dirt, smoke, and so on; oily dirt and grease; paints, tars, varnish and pitches, and acid fumes. These are given in the order in which they most frequently occur. Ordinary dirt is encountered more frequently than paints, tars or pitches, even though more lamps were selected in the latter class.

By wiping the lamps taken for this test, it was possible to increase their average light output 68.6 per cent. When they were washed they showed a total increase of 86.3 per cent in illumination. The increase in the case of those soiled with oily dirt was 147 per cent. Emphasis should be given to the fact that these figures represent the increase in light due to cleaning the lamps only. A much greater increase in useful light will result when the whole lighting unit is cleaned. Hence, the figures in Table II show very plainly that the regular cleaning, at stated intervals, of lamps and reflectors is necessary in order to avoid much waste of electrical energy and light.

The preceding paragraphs emphasize the fact that when lamps are not cleaned regularly they become very dirty, and the data given in the tables for lamps under service conditions demonstrate the surprising increase in illumination caused by cleaning. Inasmuch as it is necessary to clean lamps frequently at regular intervals, it may be ques-

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tioned how the different classes of dirt are removed by progressive maintenance men. The answer is simple, because by far the greatest number of lamps may be cleaned by the application of soap and water. Dust and dry dirt, as well as oily dirt and grease, are removed by this method. It will be found easier, however, to remove fly specks, smoke, oil and grease by the application of some cleaning agent such as Bon Ami, Old Dutch Cleanser, or Babbitt's Cleanser. The procedure for a thorough job of cleaning usually involves the removal of a group of both lamps and reflectors to a central location for washing. If desired, lamps and reflectors may be cleaned without removal from the sockets, but the results are usually not as satisfactory. After washing it is important to dry the lamps and reflectors with a cloth or in dust-free air.

Paints, tars and pitches are encountered comparatively infrequently, but are sometimes very difficult to remove by the usual methods. In these cases an organic solvent such as acetone, fusel oil or benzol will usually remove the dirt quite easily, but caution is necessary in using them. Many organic solvents are highly inflammable and their use should be carefully supervised.

It is the experience of the writer that a fair trial of the frequent application of soap and water for cleaning lamps and reflectors will reveal a surprising increase of illumination and result in a verdict demanding proper maintenance of lighting equipment.

Table I.—Increase in Illumination Obtained by Removing Various Kinds of Dirt from Lamps in Service

Lamp No.	Watts	Kind of Dirt on Lamp	Before Cleaning (Foot-candles)	After Wiping (Foot-candles)	Increase in Illumination, Per Cent	After Washing (Foot-candles)	Increase in Illumination, Per Cent
1	200	Dry machine shop dirt	14.0	23.0	64	23.0	64
2	100	Rosin vapor	.....	.....	Filament broken	.....	.....
3	200	Dry machine shop dirt	5.5	16.0	191	16.0	191
4	75	Smoke and dust	8.0	11.0	38	11.0	38
5	40	Smoke and dust	4.5	8.5	89	8.5	89
6	40	Acid fumes	7.0	11.0	57	11.0	57
7	200	Fly specks and office dirt	11.5	14.0	22	16.0	39
8	100	Rosin vapor	2.75	3.75	36	3.75	36
9	50	Linseed oil	1.75	2.75	57	2.75	57
10	150	Coke, lamp black, graphite dust	8.0	17.0	112	17.0	112
11	40	Dust and vapor from lamp black manufacture	2.75	4.5	64	4.5	64
12	40	Dust and vapor from lamp black manufacture	2.0	3.75	87	3.75	87
13	100	Dust and vapor from coke, pitch and lamp black	.....	.....	Filament broken	.....	.....
14	100	Coke dust	2.75	6.5	136	6.5	136
15	100	Carbon and pitch	.....	.....	Filament broken	.....	.....
16	25	Oily dirt from lathes	1.5	2.75	83	5.0	234
17	25	Oily dirt from lathes	2.2	4.5	104	5.5	150
18	100	Asphaltum vapors	8.5	11.0	29	11.0	29
19	100	Gum vapors	5.5	8.0	45	10.0	82
20	40	Dust from paint mixing	.....	.....	Filament broken	.....	.....
21	40	Rosin vapor	.....	.....	Filament broken	.....	.....
22	40	Paint	3.6	5.5	39	8.0*	122
23	60	Dry gypsum dust	8.0	10.0	25	10.0	25
24	60	Dry gypsum dust	11.0	14.0	27	14.0	27
		Averages	.....	.....	68.6	.....	86.3

*Organic solvent used in cleaning this lamp.

Table II.—Summary of Illumination Increases

	Kind of Dirt on Lamp	Average Per Cent Increase in Illumination After Wiping	Average Per Cent Increase in Illumination After Washing
1	Dust and dry dirt	77.7	78.4
2	Oily dirt	84.7	147.0
3	Paints, tars and pitches	37.2	67.2
4	Acid fumes*	....	....
5	All lamps	68.6	86.3

*Bulbs were badly attacked by hydrofluoric acid and bases badly corroded by muriatic and nitric acids; therefore candlepower measurements were not included.

Better Methods of Handling Materials

(*Continued from page* 45)

installation by lifting them to the required position.

Many special adaptations have been evolved. One of the best known of these is the furnace-charging truck which has now become a standard type. The platform on this is merely a set of prongs extending forward from the truck. These are run under an annealing pot and lifted as with the ordinary lift truck. The pot is then moved anywhere and deposited in the annealing furnace. This is also used for discharging the furnace and can be operated when the furnace is even too hot for a man to enter and remove the pot in any other way. With this equipment a furnace can be charged or emptied within a few hours. A slight modification of this truck has been especially designed to use in lifting heavy boxes. Another modification is used to handle rolls of paper.

As stated before in this article, no one type of material-handling equipment is always best, particularly when it is installed in an existing plant with limitations in the construction of the building and the arrangement of the departments. In such a case it is well to make provisions so that the material can be handled by any or all of the different

(*Continued on page* 67)

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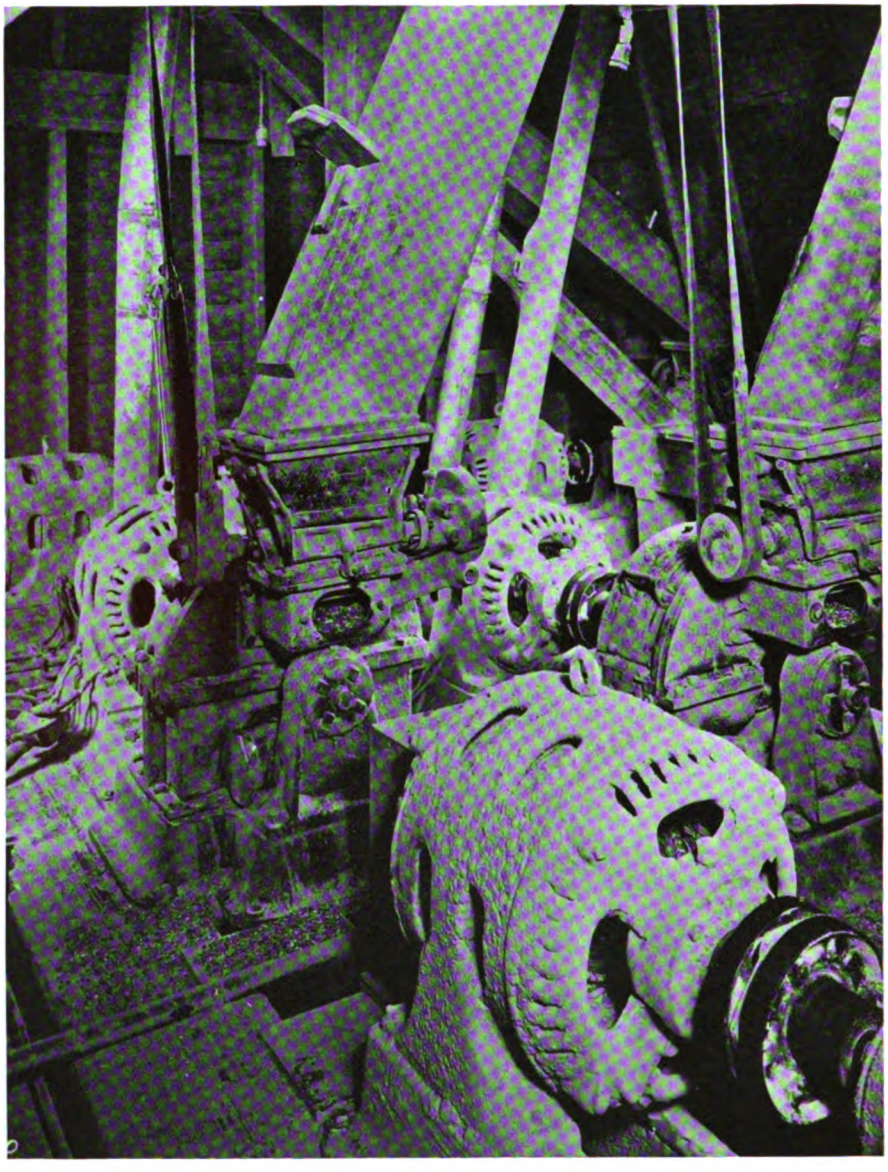
THE FUNCTION of maintenance is to keep electrical and mechanical equipment at a high level of efficiency, for the purpose of securing maximum production at the lowest operating cost. Accomplishment of this function depends on three factors: (1) Continuity of operation in the path of power service. (2) Prevention of avoidable causes of failure of equipment. (3) Conservation of equipment by proper care and periodic overhauling. Analyses of maintenance work are given in this article under each of these headings.

Some Whys and Hows of

Maintenance Analyses and Procedure

And Information Needed Before an Effective Maintenance Plan Can Be Laid Out

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer



The need for inspection and cleaning of motors under operating conditions such as shown here is self-evident. Without it continuous motor service is simply a matter of good luck rather than foresight

FROM a production standpoint the function of maintenance in plant operation is to keep the equipment on a high level of electrical and mechanical efficiency and thus make it possible to secure maximum and, so far as possible, uninterrupted production at minimum cost. The fulfillment of this function is primarily dependent on the recognition and thorough and proper analysis of three essential factors:

(1) Continuity of operation in the path of power service that extends from the point where electrical energy is received in the plant to the pulley of the machine where this service is used in machine production, or the point where this service is transferred or taken up by a machine and an operator, or by a process and a chain of machines, in the details of making a particular product or parts of it.

(2) Prevention of avoidable causes of expensive failures by the prompt detection of all weak parts and indications of wrong applications or abuse, by observation and inspection of equipment while in operation.

(3) Conservation of equipment from deterioration caused by natural wear and tear, through periodic overhauling, by proper attention to lubrication, and the immediate renewal or repair of broken parts or those that show defects which make further operation hazardous.

MAINTENANCE EMBRACES INSPECTION AND REPAIRS

Effective organization for maintenance work must be based on a clear conception of the problems in hand, as indicated by the number and character of the machines and auxiliary equipment, the nature of the product and the character of the production processes, figures on machine production, speeds and other data, as well as costs per hour and per unit of production. With these elements in mind, there must also be made a thorough pre-analysis of the probable weak points and causes of failure in various pieces of equipment, with a careful reckoning of the consequences of such failure, in order that the work may be properly directed and emphasis placed where it belongs. A production chain is no stronger than the weakest part of the drive and control equipment through which power service is supplied to the machines in this chain.

The procedure of maintenance work involves systematic and thorough inspection of all equipment by competent workmen and at intervals which in view of service conditions

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are short enough to locate weak spots before an actual failure takes place. It also involves provision of the proper facilities for making necessary repairs or adjustments either with the equipment in place or after it has been removed to a repair shop, if much work has to be done on it.

Inspection consists, of course, of a careful examination of equipment for the purpose of determining whether defects are present and in keeping a close watch of the operating condition of equipment and parts where trouble is most likely to develop. Some pieces of equipment and certain elements of each piece are much more liable to develop trouble than others; therefore in many cases a unit may be given a thorough going over once a week or once a month, while the inspector on his daily rounds will examine only those parts of it which are prone to develop trouble quickly. For example, the monthly examination of a motor and its control may involve testing the air gaps, careful examination of commutator and brushes, listening for unusual noises, smoothing contact surfaces of the line switch and starter, and so on. In the daily round he may merely feel of the motor bearings and coils to see if there is undue heating, and observe the operation for a moment to see that it is normal.

Inspection Schedules Should Be Based on a Thorough Knowledge of Conditions

The frequency and thoroughness of inspection depends in general on the severity of service conditions and also on the importance of continuity of operation. These factors and any others which are pertinent should be carefully considered when an inspection program is being laid down. In cement mills, for example, the air is constantly filled with a fine, more or less abrasive dust which rapidly cuts out bearings and wears down the commutator and all other moving parts. On the other hand, the failure of certain motors would seriously interfere with production by making it necessary to shut down other machines in order to prevent the piling up at certain points of materials in process.

Under these conditions, frequent and thorough inspection of all motors is essential for the continuity of production and the prevention of serious damage to the motors. In one representative cement mill, for example, where 235 motors are in operation, each one is carefully inspected eight times every twenty-four hours by a corps of three inspectors who work in 8-hour shifts, so that an inspector is always on duty.

The inspector on the first shift starts at 7:30 a. m. and works until 3:30 p. m. He is required to inspect every motor in the plant twice during this period. These inspections include feeling the bearings to detect undue heating, looking at the commutators and brushes, examining starting boxes, switches and fuses and checking the air gaps of the motors. In addition he replaces short or defective brushes. An average of forty brushes is replaced each day. Incidentally, brushes are replaced and the air gaps tested while the equipment is in operation. The inspector on the second shift, from 3:30 p. m. to 11:30 p. m., makes three complete rounds of the plant and oils all of the motors, besides inspecting commutators, brushes, switches and fuses, and feeling of the bearings for heating.

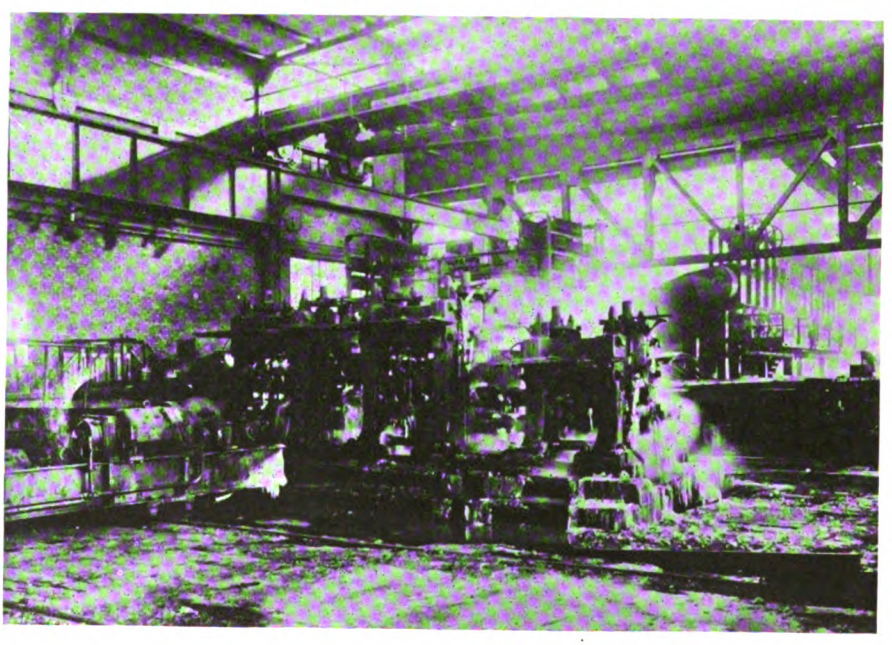
On the third shift, extending from 11:30 p. m. to 7:30 a. m., the inspector makes three complete rounds and handles any emergency repair work such as changing brushes, and so on. So far as possible, heavy repair work and replacement of equipment is done only in the day time; therefore, before the inspector on the third shift goes off duty in the morning he notifies the chief electrician of any equipment which needs immediate attention.

Aside from the three inspectors whose duties have been outlined, heavy repairs and replacements are handled by a maintenance crew consisting of an assistant chief electrician and four men. These men change armatures and bearings, wind armatures and field coils, prepare bearings, turn armature shafts, repair starting boxes and do any other repair work that turns up.

Electrical Equipment in Steel Mills Is Given Unusually Hard Service

Very severe, but different operating conditions are met in steel mills. Here the units are for the most part large, while the loads are heavy and subject to wide and rapid fluctuations which put unusual stresses on bearings, pinions and other parts of the system. In addition, the direction of rotation of many of the motors is frequently and quickly reversed, which increases wear and tear. There is less dust and abrasive matter in the air than is found in cement mills, but the combination of steamy or greasy atmosphere with metal and carbon dust, derived in part from the brushes on the machines, causes a good deal of trouble. Unless this dust is removed frequently it will form a leakage path between the slip rings and may break down and cause flashovers when an attempt is made to start the motor.

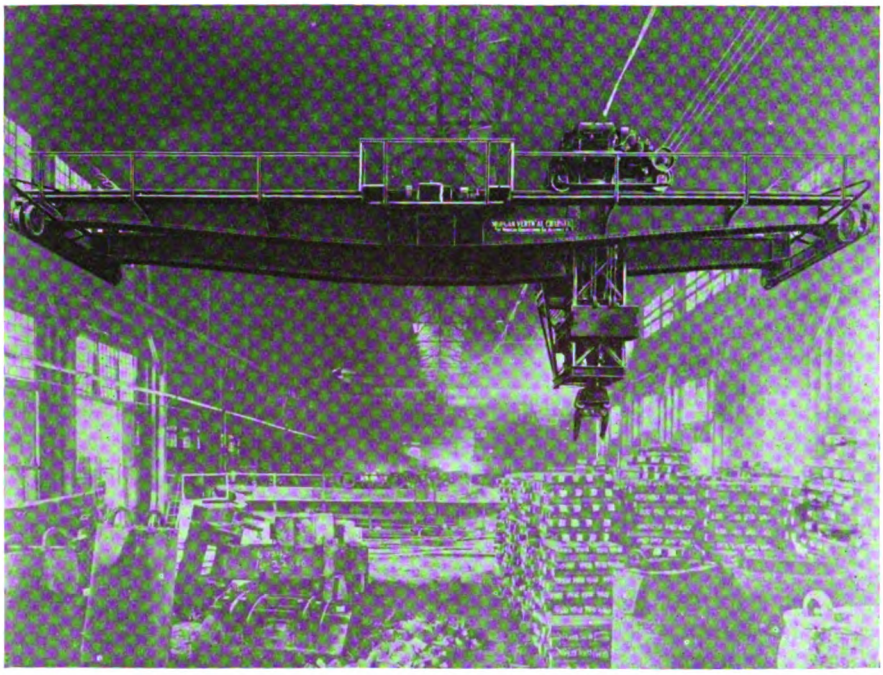
Another condition which adds to



Steel mill motors are often exposed to extremes of heat and cold and dampness.

This is an 18-in. structural mill, comprising two 3-high and one 2-high roll stands, capable of rolling 7-in. I-beams and 4-in. by 4-in. angles. This mill is located in the South Bethlehem, Pa., plant of the Bethlehem Steel Co.

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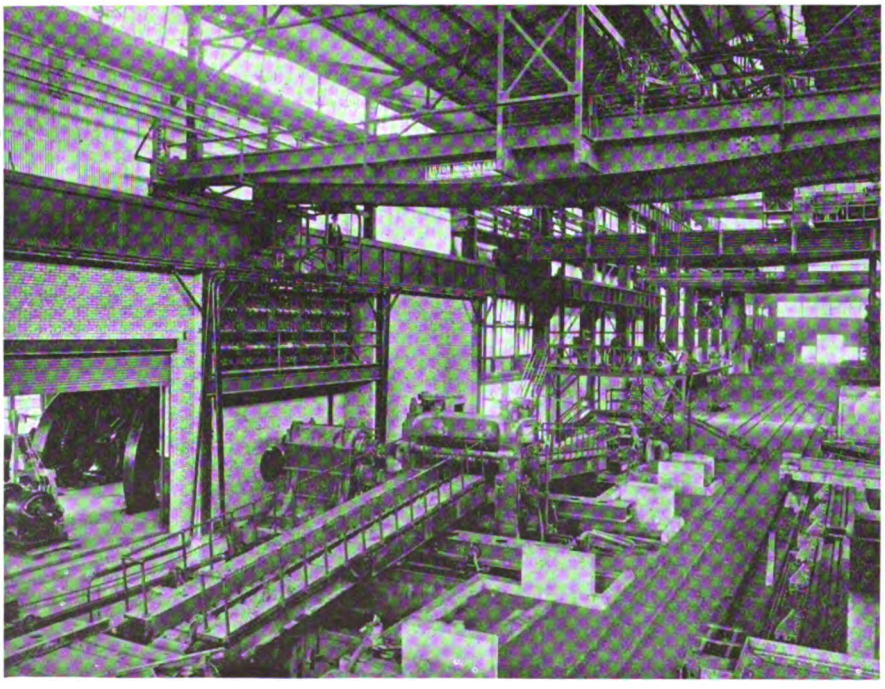
Failure of this crane may cause serious delay and loss.
This is a 7½-ton, stiff-leg type crane, with a 60-ft. span and equipped with five motors. It handles hot metal in and out of the soaking pits in the plant of the United Alloy Steel Corporation, Canton, Ohio.

the severity of the service is the constant starting and stopping, so that the motors, in many instances, operate a large part of the time under starting conditions. This means that commutation is poorer than in the case of motors which operate more or less continuously, and that all parts of the machine are subjected to unusually hard duty.

Again, motors in some locations, for example, around furnaces or on cranes which handle ladles of molten metal, are exposed to comparatively high temperatures, a condition which is not conducive to long life.

Here, also, the failure of an important crane or mill motor may not only produce a serious break in the chain of production, but cause considerable loss by leaving tons of hot metal in a partially finished state.

In order to prevent such occurrences, a close watch in the form of daily inspection and cleaning must be kept of all motors and control equipment. As an example of what this involves, the schedule followed in one large steel mill is of interest. A daily inspection is made of all important equipment to detect any symptoms of trouble in operation. In addition to the inspection, once each week all motors, controllers and switchboards are cleaned, carefully inspected and any worn or defective parts repaired or replaced. Every two weeks the air gaps on all motors are tested, all master and drum controllers overhauled, and the operation of magnetic controls inspected. Magnetic controls are carefully inspected and all circuit breakers overhauled at intervals of three weeks. At four-week periods the collector rings are cleaned, oil switches and brushes on all apparatus, including motors, overhauled, all motors are tightened up, pulleys and couplings inspected, rotary, direct-current breakers tested and the voltage drop on all circuit breakers determined. Other inspection, testing or overhauling operations are scheduled at intervals of six weeks, two months, three months, and so on.



A 30-in., 3-high billet mill.
This mill is equipped with combination tilting, lifting and traveling tables. It is located in the Lebanon, Pa., plant of the Bethlehem Steel Company and is used for reducing 14-in. by 14-in. ingots down to 2½-in. to 4-in. billet. The motor is protected by housing it in a separate room.

Material-Handling Equipment May Be the Key to Continuous Production

In the instances which have just been cited particular emphasis is placed on keeping in service the motors driving the various machines in the production scheme. Sometimes, as in the case of plants which turn out a very bulky or heavy product, the key to continuous production lies in the cranes or similar material-handling equipment which is employed to transport the product or its component parts from one machine or operation to another. Under these conditions, while the failure of a motor driving a machine tool may cause annoying delays and loss of production, it will usually not be so serious as the failure of a crane which serves a number of machines. In this case all of these machines may have to stand idle until the necessary repairs can be made and the crane put into service again.

An example of these conditions is found in a large plant which makes screws and bolts exclusively. Practically all of the raw material and finished product is handled to and from the machines by eight electrically-driven traveling cranes, several

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of which serve a number of machines. Inasmuch as the failure of one of these cranes will tie up production in a very short time, every effort is made to keep the cranes in good operating condition at all times. To this end a very thorough inspection of all cranes is made every Friday. At this time the motors, brushes, switches, controller, gears, bearings, tracks and wheels, sheaves, hooks and chains, in fact every part, of the crane is carefully examined and an inspection report form made out showing the condition of these parts. These report forms are given to the assistant chief electrician. He notes the items carefully and turns them over to the chief electrician, who checks in red the repairs he wishes to have made at once. In this way both the assistant and the chief electrician have at all times an accurate knowledge of the condition of the cranes and the extent and character of the repairs which are necessary.

This should not be taken to mean that the motors and controls of the machines which turn out the plant's product are neglected. These are subjected to an inspection routine which is adequate and rigidly enforced. But, as is proper, more emphasis is placed on keeping the cranes, which are the key to the production program, in the best possible working order.

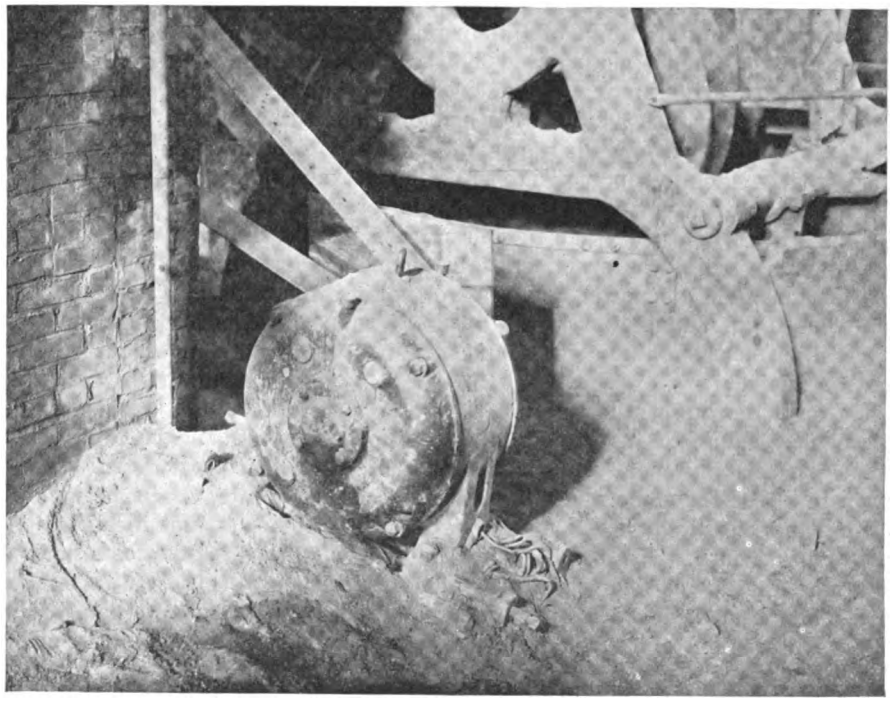
Somewhat different conditions obtain in plants where each machine turns out a product that is either practically ready for the market, or is sent to stock to be withdrawn later on. In such cases the loss of the services of one or two machines through failure of the motor or other power equipment will not seriously interfere with the production of the plant as a whole. A case in point is found in a certain plant whose product consists of a large number of small parts. Practically all machines are individually driven and with a few exceptions a number of machines are employed to turn out the same part. As they come from the machines all parts are sent directly to the stockroom and withdrawn in accordance with the needs of the assembly department. A sufficiently large stock of each part to supply the assembly department for some time is kept on hand; therefore, the failure of a motor which drives one of the lathes or punch presses is not immediately serious, from the production standpoint. Of course, failures are expensive under any circumstances, in that it costs money to replace and repair a motor and to have workmen and machines stand idle, and every reasonable precaution is taken to avoid them. In this plant, experience coupled with a careful balancing of the cost of inspection against the probable frequency and seriousness of motor failures has shown that a careful examination of all motors once or twice a week, with a complete overhauling every six months, will serve to keep them in good condition and reduce to a minimum the failures from preventable causes.

Written Schedules for Maintenance Work Avoid Confusion and Fix Responsibility

After the analysis of the objects to be accomplished and the decision as to the methods of attacking the problems, there must be provided schedules or written instructions covering: (1) Daily routine duties; (2) periodic inspections of machines and equipment; (3) periodic overhauling of machines and equipment; (4) procedure for scrapping or placing any piece of equipment on the obsolete list. Unless this is done, vital points in the maintenance program are almost certain to be overlooked or misunderstood and it will be difficult to fix responsibilities definitely. Some system of inspection and repair reports must also be worked out in order that a proper check can be kept on the work. In the absence of some method of checking, interest will lag, the hard jobs will be overlooked or slighted and haphazard guesswork will take the place of the definite, clear-cut methods of procedure which are essential if the desired results are to be obtained.

This does not mean that maintenance work should be bound up hand and foot with red tape. It is unreasonable to ask a man who is inspecting every motor in a large plant three times a day to make a detailed report of each inspection. It is just as bad, or worse, not to require any reports. It is possible, however, to work out, somewhere between these extremes, a system of inspection reports which will be adequate under the character of the operating conditions which obtain.

For example, in one plant which operates a large number of small and medium-size motors, the inspection schedule calls for a thorough examination of each motor once a week. Most of the machines in this plant are individually driven, and inasmuch as the service conditions are not unduly severe, a weekly inspection has been found to be satisfactory. The inspector carries with him in his rounds a report form on which is entered the number of each motor. Opposite this number there are four columns, each headed by the date on which the inspection is made. (*Continued on page* 65)



Lack of attention to motors operated under conditions like this is the cause of high repair bills.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, January, 1923

A Happy New Year to You All

FOR INDUSTRIAL ENGINEER this issue marks its first birthday under that name and its present scope of service to men in industrial works. The occasion is a particularly fitting one as we look into a new year with new hope and new inspiration, to express appreciation for the full measure of co-operation that 127 contributors have given us during the year past and to wish for the 15,000 men who make up our family of readers Health, Happiness and Prosperity during the year we are just beginning.

An Ounce of Inspection vs. A Pound of Repair

CONCLUSIVE proof of the value of organized inspection and maintenance work in preventing failures and reducing the cost of repairs to equipment was recently obtained by a well-known company, which operates about 3,000 motors and 300 traveling cranes in a works covering many acres of ground.

When the business depression came very radical reductions were made in the number of employes, particularly "non-producing" labor. Most of the electrical department inspection and repair crews were included in this category and in consequence systematic maintenance work was practically abandoned. As was to be expected, the power and control equipment got into such bad shape that when business revived the necessity for proper inspection and repair work could not be denied.

After a thorough study of the situation a carefully planned schedule of inspection, cleaning and oiling of all electrical equipment was instituted. When it had been in effect for some months, the cost of inspection, oiling and cleaning was found to be about $1.50 per motor per month. The credit side of the ledger showed that the shutdowns due to failures of electrical equipment had been reduced 75 per cent. In other words, three failures out of four could be prevented by spending $1.50 per month in maintenance work. Anyone who is responsible for production or maintenance knows that even a minor breakdown of a motor or other interruption to power service may cost many times this amount.

With some variation in details this same incident has been, or could be, told of nearly every industrial works. It is cited as showing the fundamental truth of the saying: "An ounce of prevention is worth a pound of cure," which bit of wisdom is so old that apparently its very antiquity sometimes keeps it from being taken seriously.

The Remedy for Breakdown Alibis

IN a recent address on "Conservation of Plant and Equipment," Emil J. Schmidt, Industrial Engineer with Sewell-Clapp Envelopes of Chicago, started out with this sentence: "A smooth running plant is no accident." Then he proceeded to analyze the vital steps embraced in conservation and in dealing with plant operation, he said:

> "How is maintenance handled? Is there a separate department for it? How is it controlled? What equipment in particular has the maintenance department for doing its own work? We need all the available figures on machine production, speeds and other machine data, costs per hour and per unit of production.
>
> Get the facts! All the facts! Analyze the facts! The management is then in a position for setting standards, based on definite policies. These had better be written, to be clear and concise. Standards would include performance, maintenance expense and also standards of supervision.
>
> Schedules or written instructions can then be provided for: (a) Daily routine duties of functions in maintenance work; (b) Periodic inspection of machines and equipment; (c) Periodic overhauling of machines and equipment; (d) Procedure to be followed when any piece of equipment is scrapped or placed on the obsolete list.
>
> The best system, the most alert executive, will not succeed fully without co-operation. This is particularly true of maintenance work. The engineering department, superintendents, foremen, all must co-operate fully in order that the maintenance department can really do all that the executive expects. The first-class executive (and this is the only kind that we are discussing) knows this, and he will see to it that co-operation is secured.
>
> In all of this, if it is to be thoroughly analyzed and handled, need we say that the industrial engineer, or someone who has his viewpoint and uses his technique, is absolutely indispensable?

Unquestionably it is this kind of thinking that is most needed in all industrial works where new production schedules and new plans are being laid on which future profits will depend. This thinking from a production standpoint must be injected all along the line from the receipt of an order from a customer down through all the processes to the shipping platform. In this issue another phase of the same thinking is taken up by Arthur J. Whitcomb. In the first of four articles he lays down the basis for an accounting of maintenance procedure while the work is going on as a perpetual check on the cost of the unexpected that shows up in breakdowns, losses in production at machines and in entire departments. Such an index to production costs cannot be figured accurately in advance but the data from a perpetual accounting of procedure in maintenance will show up certain plant deficiencies in equipment and methods without the painful post mortems at the end of each quarter of the year when

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discussions on dividends bring up facts and figures and plenty of alibis and explanations for the things they should not show.

Key Motor Installations

IN HIS contribution to our analysis of maintenance practices presented in the table on page 32 of this issue, J. H. Gallant, Chief Electrician of the Canada Cement Company, Belleville, Ontario, uses the term "Key motor installations." He applies it to the use of motors on conveyors, elevators and the like, which carry materials or parts in process to or from machines or other departments.

This is a very apt term. It calls attention to a point in the chain of power service in any works where this sort of equipment is installed, that must be strong enough to take more than ordinary jolts during its entire period of service. When equipment is new and running nicely, failures at these points are not expected, but the inevitable weakening as the result of natural wear and tear must be taken into consideration if the strength of this link in the chain is to be maintained at its original value. This means regular and periodic inspections, replacement of worn and weak parts as the inspectors locate them; and a thorough overhauling at such intervals as the records of inspections will indicate are necessary.

It is an unfortunate condition when these key motor installations are ignored until a breakdown takes place, for then an emergency situation is created that must be attended to like a fire with an unavoidable waste in production, time and often materials in process, especially when hot metals are being handled—a waste that depends entirely upon how quickly steps in repair can be set in operation. The old saying that "A stitch in time will save nine," is a good one to put into actual practice in the maintenance of these key motor installations.

Is Maintenance Work a Luxury or a Necessity?

IN A CONVERSATION with an engineer who has had many years of experience in maintenance work, he recently said: "When a man has to fight with his boss at every turn of the road to get permission to do his work properly, he surely has a life-sized job on his hands." The truth of this statement is apparent without argument or demonstration. Anyone who is handling a real job in the way it should be handled usually has his full share of burdens, under the best of circumstances. But if, in addition to his work, he has to contend with a hostile, penny-wise-and-pound-foolish managerial policy, his load is increased manyfold.

Failure to appreciate the importance of maintenance work is, no doubt, often due to the fact that it is hard to show in dollars and cents just what the returns are. Maintenance is not a gold bond bearing a guaranteed rate of interest, payable quarterly. It is insurance against costly interruptions of production through the failure of equipment. It has justified itself if it has kept the wheels turning by the elimination of all preventable causes of failure. Some conception of the value of maintenance work can be obtained by calculating what it would mean in loss of production, wages of idle employes and so on, to lose through breakdowns the service of an important motor and its driven machine for one hour. If this were an actual occurrence there would have been added to the above figure the cost of repairing the motor, which might easily amount to a hundred or more dollars. While this is not an insignificant item, the other losses may be much greater unless production can be started again either through the substitution of auxiliary or stand-by equipment. A few such failures in the course of a year would pay for a good deal of maintenance work. Needless to say these truths are just as applicable to the maintenance of lighting, call or alarm systems and similar factors as to motors and the mechanical equipment with which they are associated.

The Aim of This Issue

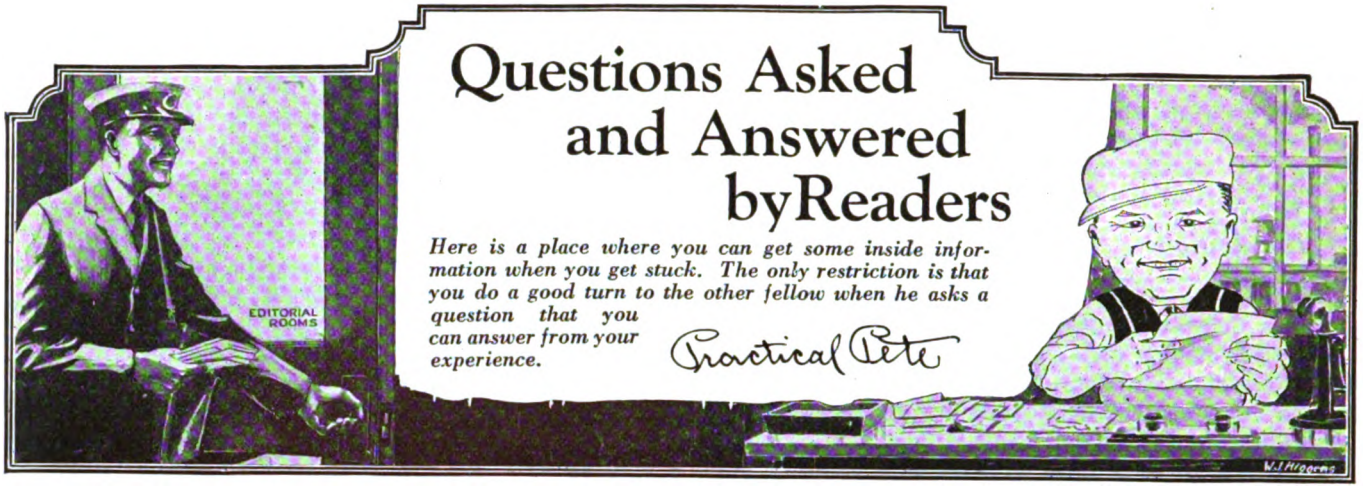
THIS ISSUE of INDUSTRIAL ENGINEER starts the second year of its service to men in industrial works responsible for the operation and maintenance of electrical and associated mechanical systems. In the twelve issues that have gone before, specific instances have been dealt with where special attention has been directed toward maintenance thinking and maintenance needs, and information given on the analysis of the work involved and the results secured. In each case the "hows" and the "whys" of maintenance have been discussed so that the men who are planning this work and those who are carrying out the details can go where they are looking and look where they are going in contrast with the futility of the blind trying to lead the blind.

In studying maintenance problems during the past twelve months the occasion has repeatedly come up to compare the methods followed in one large works with those of another and the results of each. In every case the variations in the results secured seem to lie in the degree of organization of maintenance work and the kind of facilities present to carry it out. In other words, the results are a measure of the kind of thinking that is given to maintenance needs by those who have the ability and experience to work out the practical applications.

In this issue, therefore, we have assembled articles that represent the backbone of maintenance thinking and in an analysis of maintenance procedure of seventy-four industrial works, a picture is presented of how this work is being handled and the attention devoted to it. This particular analysis deserves a great deal of study. It is the first complete report of its kind to be presented as far as we know and it will be improved and made better in each January issue of INDUSTRIAL ENGINEER hereafter.

If any of our readers spot particular points of interest on which they would like special or detailed information, the editors of INDUSTRIAL ENGINEER will welcome such requests. Investigations will be made along the lines suggested and the results presented in the issues of 1923.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Construction of Testing Transformer—I would like to know how to make a small transformer for testing purposes that will step up from 110 volts, 60 cycles to 550 and 1100 volts. Please give the size of wire for the primary and secondary and show by a diagram how to put on the windings and make the taps. Also give dimensions of the core and insulation that should be used.
Tyrone, Pa. H. L. F.

* * * *

What Makes a Safety Switch Safe?—When installing safety switches the user has in mind protection from fire and safety hazards. I would like to see published in INDUSTRIAL ENGINEER comments from both users and manufacturers of safety switches on what they consider the essential points in the construction and use of the enclosed type safety switch.
Detroit, Mich. J. H. R.

* * * *

Trouble With Brushes—I have a 200 kw. d.c. generator driven by a synchronous motor. The brushes groove badly but do not arc. They are staggered and the commutator has been slotted and turned. The brushes seem to show a hard spot and cut the copper. This machine has a varying load and operates at 1200 r.p.m. A remedy for this brush trouble will be appreciated.
Madrid, Iowa. F. M.

* * * *

Cutting Out Coils in D. C. Machines—In the August number on pages 386 and 387 I was interested in the drawings by A. C. Roe. In the four- and eight-pole armatures I have noticed that the slots and segments were an odd number, while in the six-pole armatures the slots and segments are an even number. Will someone explain whether or not it makes any difference if the slots and segments are even or odd in both lap and wave windings when cutting out coils?
Richmond, Va. R. E. L. R.

* * * *

Expansion and Contraction of Steel Trolley Bar—What allowance must be made for expansion and contraction, due to changes in summer and winter temperatures, of a steel trolley bar 625 ft. long on an outside crane runway? This will be a (10 point carbon composition) rod 0.342 in. in diameter with supports 10 ft. apart. What is the best method of anchoring this rod to allow for this expansion?
Gary, Ind. A. L. G.

* * * *

Reconnecting Motors for Half Speed.—We have two 7½-hp., 60-cycle, 220-volt motors operating at 1800 r.p.m. These motors are connected in two-parallel delta. They have 40 slots with 4 coils in a group. Is it possible to reconnect the winding for a speed of 900 r.p.m. and get as good performance from the motors as when they were connected for 1800 r.p.m.?
Medina, O. C. F. N.

* * * *

Why Does This Motor Reverse?—What would cause a 2-hp., d.c. compound motor, when a heavy load is thrown on, to reverse its direction of rotation? It can be started in one direction and then stopped and the next time it is started it may run in the opposite direction.
Toronto, Canada. J. H. M.

Answers Received To Questions Asked

Heat Resisting and Insulating Cement.—I have been referred to the INDUSTRIAL ENGINEER by the A & M College of Texas for a good type of heat resisting and insulating cement and also a kind of insulation that will take the place of porcelain. We desire an insulating material that can be shaped, drilled when necessary and will stand heat if exposed to fire. Any information you can furnish will be appreciated.
Bartlett, Tex. A. C. H.

In answer to the question by A. C. H. of Bartlett, Texas, as to a heat resisting insulation which can be drilled and shaped, I would recommend Bakelite. It can be used for dipping or in its hard form it can be shaped, drilled, turned and tapped. The hard form can be bought in sheets or plates like fiber, tubes, rods, etc., and specially molded. It is fire and water proof and a very good insulator. Bakelite can be bought from the manufacturer in liquid form, or hard form, and it stands heat like mica and will not soften. It is made by the General Bakelite Company, New York City.
Chicago, Ill. CARL STEINIGER.

* * * *

In answer to A. C. H., whose inquiry was published in the November issue, we have found liquid glass ($Na_2 Si_4 O_9$) to be a good heat resisting insulating cement for many purposes. When mixed with soapstone powder it makes a good insulator. It may be mixed up to any consistency from paint to plaster, and will air dry or may be baked. A brick made of it may be machined or drilled. Try it for covering a resistance or heater coil wound on an asbestos tube, or for repairing.
Lead, S. Dak. R. F. CRAWFORD.

* * * *

In regard to the inquiry in INDUSTRIAL ENGINEER by A. C. H., concerning heat resisting and insulating cement, I would refer him to D. M. Stewart Manufacturing Co., Chattanooga, Tenn., manufacturers of "Lavite," which I think would answer the purpose. The American Lava Corporation, 1419 William St., Chattanooga, Tenn., is also engaged in the same line.
Chief Engineer, PHILIP N. EMIGH.
Mountain Water Supply Co.,
Indian Creek, Pa.

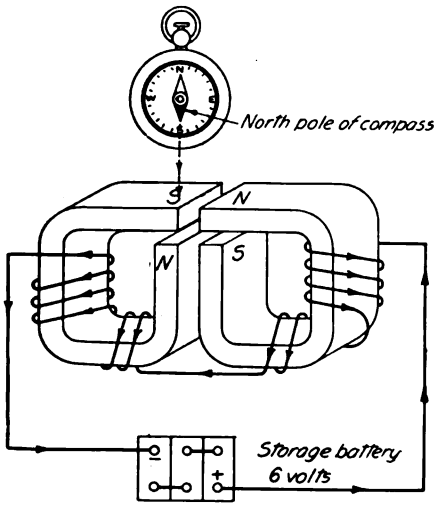
* * * *

Remagnetizing Magnets.—Please show a good method for remagnetizing magnets such as used in magnetos and kilowatt-hour meters.
Dixon, Ill. G. L. H.

When the permanent magnets of a watthour meter become weak through accidental short-circuit or lightning stroke, it is very easy to remagnetize them by removing them

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from the meter, wrapping with a short piece of heavy flexible wire as shown in the accompanying illustration and making several short-circuits on a well-charged auto-



Proper direction of current flow for remagnetizing magnets.

starting storage battery. These "shorts" should only be a fraction of a second in duration or the wire will become hot; and the actual time required by the current to do the magnetizing is almost inappreciable. It is advisable to get the polarity correct. This can be best accomplished with a compass, using the right-hand rule for current flow and magnetism. The accompanying sketch will show the relation between direction of current and magnetic polarity.

If a good battery is not available, connect to a d. c. generator of at least 50 kva. capacity in series with a single pole knife switch and about a 30-amp. fuse. Close the switch quickly, thus making a "dead" short and blowing the fuse. It is advisable to make 2 or 3 "shorts" to insure saturation of the iron.

The magnet may also be magnetized by blowing a fuse on a 25-cycle circuit, but although the fuse always blows on the peak of the wave, the polarity will be unknown and only one "short" should be made.

The magnet is now fully saturated and should be artificially aged to insure permanence. This is done by passing about 100 amp.-turns of 60 or 25 cycles around the magnet. For instance, if we have 10 turns per magnet, then pass 10 amps. Eight turns, pass 12 amps., etc. This must be passed by building the current from a low value to its maximum by means of an adjustable liquid, carbon, wire slide or reactive resistor. Let the current stay at its maximum for about 2 minutes, gently tapping the magnet with a brass rod if desired, and then decrease the current gradually. The circuit must not be broken quickly on a. c. current.

If after replacing the magnet on the meter it is too strong to allow adjustment, it may be removed and aged with 150 or 200 amp.-turns a. c. until it has the proper strength.

Aging may also be accomplished by using a coil of wire about 6 inches in diameter, wound with 1,200 or 1,100 turns of about No. 24 B. & S. copper. Connect this coil to a 110-volt, 60-cycle circuit and hold it about 5 or 6 inches from the magnets, the exact distance depending on experiment, to determine how much demagnetizing is required.

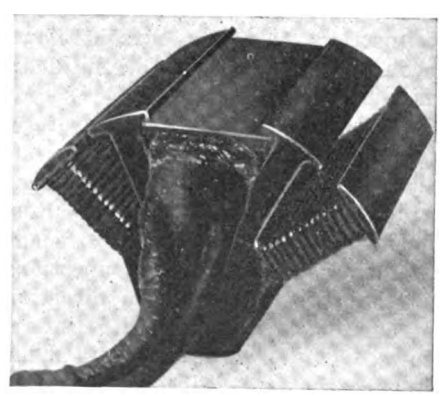
Summit, N. J. VICTOR H. TODD.

* * * *

Device for Testing Windings of Small Motors. — Will someone be good enough to describe a small testing transformer or similar device such as described on page 45 of the January issue of INDUSTRIAL ENGINEER, that can be used for testing the windings of fractional horsepower motors for short-circuits, grounds, open circuits, and the like?

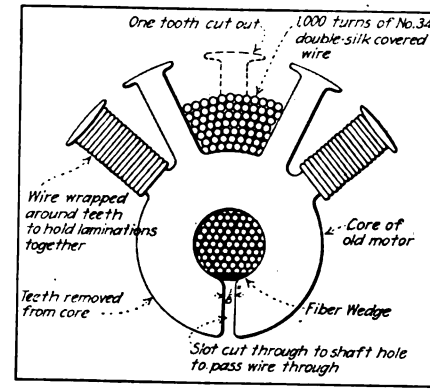
Nanty-Glo, Pa. S. J. S.

Regarding the request of S. J. S. for a simple test to locate grounds and short circuits in small stators, the following will describe a testing outfit for use on 110 volts, 60 cycles, which we made in the shop. We removed the shaft from an old d. c. fan motor armature and cut off the teeth as shown in the accompanying sketch. A slot was then cut in one side to allow the wires of the winding to be inserted in the hole formerly occupied by the shaft. A thousand turns of No. 34 double-silk-covered wire were wound on. After the winding was put in, wedges were inserted to hold it in place. Lamp-cord leads were fastened to the growler and taped.



Growler used to locate grounds and shorts in small stators.

To test for shorts, this small growler is placed on the stator teeth and a tin feeler is used across the slots, one coil pitch in advance of the growler. If the tin vibrates there



Details of construction of small growler.

is a short in that slot. To test for grounds, place the growler on the core and then touch one lead of the stator winding to the iron core. If a spark is produced, the winding is grounded. This test can be made after a stator is rewound and before connecting it up. Try each coil in the starting and running winding. The slot the ground is in can be located by making a good steady contact with one lead of the grounded coil to the stator core; then apply the growler and use the tin feeler to bridge the slots until it vibrates.

Detroit, Mich. A. C. ROE.

* * * *

Small Condenser for 110-Volt A. C. Circuit.—I want to make some experiments with condensers on a. c. circuits of 110 volts, the capacity of the condensers to be approximately one microfarad. 1. Where can I obtain the necessary sheets of tin foil? 2. What should I use for the dielectric? 3. Where can I obtain same? 4. What thickness should the dielectric be for 110 volts a. c.? I have never seen any of this material advertised, consequently this request to you.

Logansport, Ind. L. E. G.

If you desire only a small number of condensers of 1 m.f. capacity, it would undoubtedly be best to purchase them from some electrical store, or, if you are not able to do this, I would suggest getting a telephone condenser through your telephone exchange. A 1 m.f. condenser should not cost over $1.50 or $2, which would be much less than you could make the condenser for.

In making such a condenser aluminum foil is usually used at the present time and can be obtained from the Aluminum Company of America, which has offices in all large cities.

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The thinnest foil made by this company, which measures about ½ mil in thickness, is the foil used. The dielectric is paper and the thickness of this paper runs from ½ to ¾ mil. This paper is very difficult to get, as it has to be purchased under specifications as to freedom from pin holes and conducting particles. Good specifications limit these conducting particles to sixty per square foot. If you intend to make your condenser of sheets stacked by hand probably the best paper that you could get would be a good grade of closely woven toilet paper of the thinnest tissue possible. This, I understand, is the thinnest commercial paper made. About two sheets of this paper should be sufficient for 110 volts. It would require about 18 sq. ft. of foil for 1 m.f. capacity when spaced with two sheets of ½-mil paper. After the condenser is formed it should be impregnated with paraffin under a vacuum.

L. J. MERRILL.
National Electric Condenser Co.,
Philadelphia, Pa.

* * * *

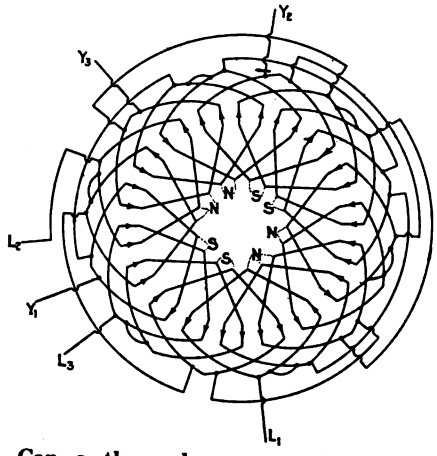
Changing Single-Phase Motor to Three-Phase.—I wish to change a Wagner motor over from single-phase to three-phase. What will be the requirements? Should I short-circuit the commutator? Will there then be enough copper in the rotor? I shall have to change the stator and distribute the winding from four concentrated poles to four or six distributed poles. Should I use the same length and gage of wire to do this or should I figure on more wire and a smaller size? The motor has No. 12 or No. 13 in the fields now.
Ardmore, Okla. R. W. MCMURRAY.

The stator winding will have to be redesigned for three-phase operation. The method outlined in A. M. Dudley's book, "Connecting Induction Motors," could be used. Regarding the rotor, after the stator has been rewound for three phase, the commutator on the rotor could be shorted and the motor tried out under load conditions to see if the present rotor winding will develop enough starting torque to start its load. If O. K., the brush rigging and centrifugal device can be removed and the commutator permanently shorted by burring over the commutator bars.

If more starting torque is required the rotor can be rewound with 10 per cent more turns and smaller size wire. Remove the commutator completely and connect the beginning and ending of each coil together, i. e., short circuit each.

Detroit, Mich. A. C. ROE.

Is This Motor Connection Correct?—I should like to know if the accompanying diagram of a motor winding is correct. This is for a three-phase, four-pole, 60-cycle, 36-slot motor with an 18-coil basket winding. If this connection is not correct I should like to see the right one published.
St. Anne de Beaupre, Quebec, Canada. E. L.



Can a three-phase motor be connected like this?

The accompanying sketch shows the connections for coils to permit proper operation of the motor referred to by E. L., St. Anne de Beaupre, Quebec, Canada. The numbers in the wiring diagrams, 1 and 2, indicate in the first case one coil-per-group-per-phase and in the second case, two coils-per-group-per-phase. The two coils, of course, are connected in series.

The arrows in the diagram indicate the direction of current in the coils at any one moment. When checking a three-phase circuit it is convenient to imagine that the current flows in the same direction in two legs of the circuit and in the opposite direction in the third leg. In applying this scheme to a motor diagram such as shown it is necessary to assume that the current flows in all three leads of the star connection toward the point of the star connection. In the case of a delta connection, that the current flows around the three sides of the delta in the same direction.

In using this diagram, therefore, the repair man need only lay out the required number of pole-phase groups and then draw arrows alternating the direction of their heads and draw in the jumper connections so that the instantaneous direction of current corresponds with the arrows. This arrangement will make it sure that the leads of the three phases of a motor are brought out to an electrical angle of 120 deg apart. This is usually a separation of two poles.

The method of drawing these diagrams is fully explained in "Armature Winding and Motor Repair," by D. H. Braymer, pages 52, 53 and 236. The applications of the diagrams are fully explained on pages 261 to 300 with many diagrams for motors of different poles and types of connection.

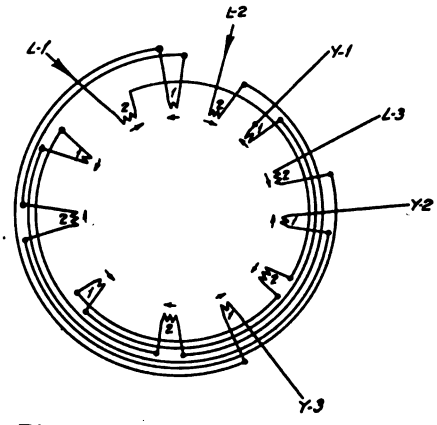


Diagram showing connection of pole-phase groups for motor question asked by E. L.

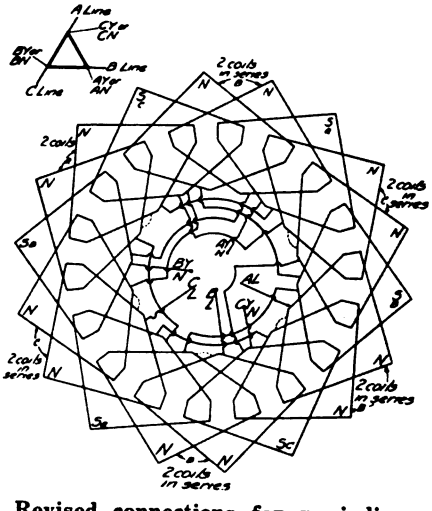
Richmond, Cal. U. O. MEISNER.

* * * *

The diagram of stator winding for the 3-phase motor shown by E. L. of St. Anne de Beaupre, Quebec, Canada, is not correct. In the accompanying drawing I have sketched the winding connections that can be used for winding this motor as a 4-pole, single-circuit Y with 18 coils and 36 slots.

In this diagram six coils per phase are used with a combination of one and two coils per pole and one coil per slot.

Allentown, Pa. CARL W. HEIMBACH.

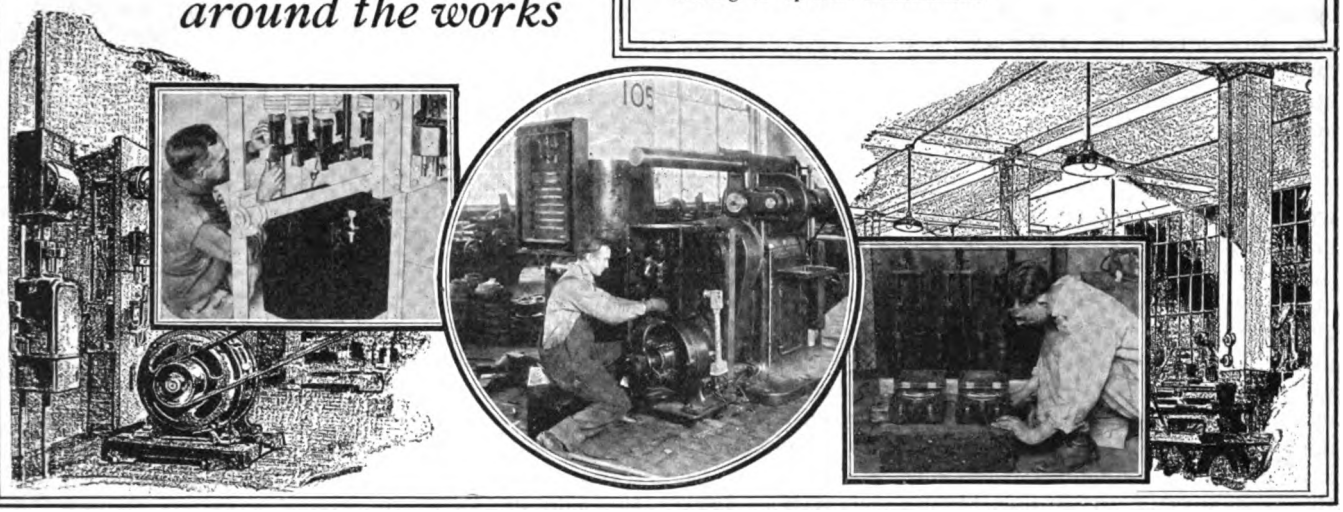


Revised connections for rewinding a 36-slot, 4-pole, 60-cycle, 3-phase motor.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Lighting Up of Signal Lamp Indicates When Pump Accidentally Stops

A DEVICE which gives a signal when the circulating water ceases to flow to an internal-combustion engine, is in use in a plant in St. Louis, Mo.

The water for cooling the cylinders of this 300-hp. engine is obtained from a driven well. The supply being limited, it was necessary to install a cooling tower so the same water may be used continuously. The water is circulated through the cylinder jackets of the engine by means of a motor-driven centrifugal pump. The pump takes its suction through a pipe which descends vertically from the sump beneath the cooling tower and sends its discharge through the jackets and thence to the top of the tower.

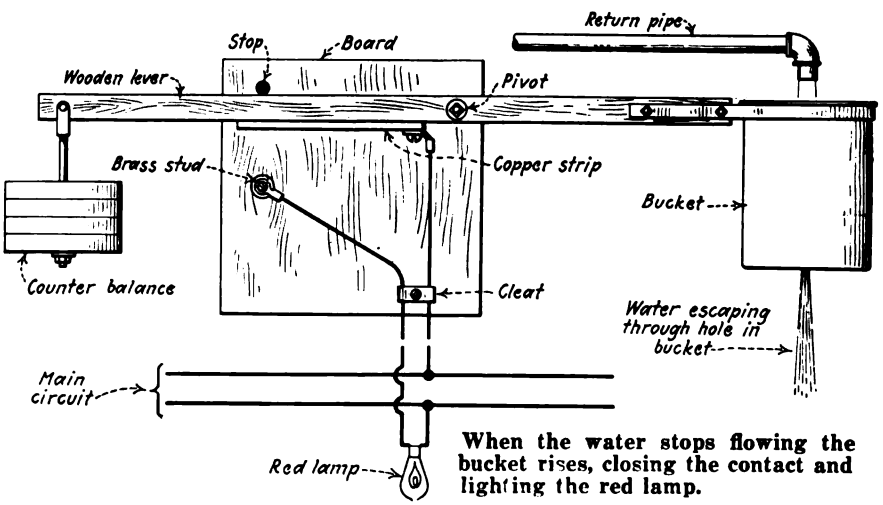
One day the circulating pump stopped, due to the blowing of a fuse in the motor circuit, and before the attendant became aware of the stoppage the engine also had dropped out. To prevent a repetition of the trouble the attendant determined to make a device that would give him immediate notice of stoppage of the jacket-water circulation. After considering various schemes he finally hit upon the idea shown in the sketch.

A wooden lever, about 5 ft. long, is pivoted at its middle point on a stud projecting from a board which is secured in an upright position at the top of the tower. A piece of strap iron, bent into a ring for holding a galvanized-iron bucket of about 1-gal. capacity, is bolted to one end of the lever. A set of counterbalance weights are hung from the other end. The bucket, which is hung directly beneath the outlet of the pipe which returns the water to the tower, has a 3/8-in. hole in its bottom. When the circulating pump is running, the returning water overflows the bucket.

When the circulation is just right the weight of the water in the bucket is counterbalanced by the weight hung on the opposite end of the lever. The lever then stands horizontally. But if the circulation ceases from any cause, the water runs out of the bucket through the hole in the bottom. The weighted end of the lever then falls and the copper strip, which is secured to the lower edge of the lever, makes contact with the brass stud, thus closing the circuit through a red lamp which is located conspicuously in the engine room.

A galvanized-iron shelter is built over this device to protect it from the elements and from the spray blown from the tower as the arm might freeze solid. A. J. DIXON.

St. Louis, Mo.



When the water stops flowing the bucket rises, closing the contact and lighting the red lamp.

Drying Out Motors Which Have Stood in Damp Location

IF AN electrical machine has been standing idle for some time and exposed to much moisture, it should be dried out before going into service. Often it is difficult to get the right voltage, and so forth, for drying by passing current through the windings. A case of this kind which needed some ingenuity to work out the right method was recently handled by the writer.

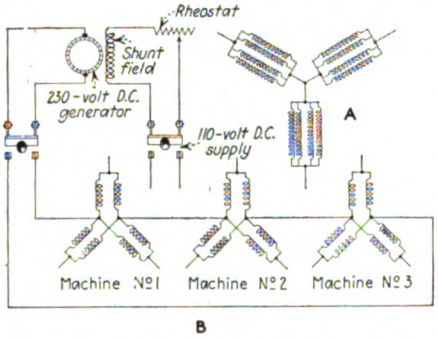
This was in connection with drying three 440-volt, 275-amp., 250-hp., three-phase, 60-cycle synchronous motors direct-connected to compressors in an industrial plant in New

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York City. After these motors were erected and before they were ready to be operated they were subjected to severe conditions of moisture, so that it was not considered safe to operate them without drying them out. An examination of the winding disclosed that it was a four-circuit star winding as shown in *A* of the accompanying drawing.

The only available current for drying out was from a compound-wound, 230-volt, direct-current generator with a rating of 230 amp. In order to be able to use this current and obtain good heating effect on the windings it was necessary to place as much of the windings in series as possible, with the minimum amount of work. This was done by taking any two of the four star points in each phase and putting the current in at one of the star points and out at the other, as shown at *B*. By connecting the three machines in series a voltage of approximately 65 volts and an amperage of 250 amp. was required to maintain a temperature of 185 deg. F., which was very satisfactory. By maintaining this temperature for thirty hours the motors were thoroughly dried out. To obtain this voltage and current the series winding of the generator was disconnected and the shunt field separately excited from a 110-volt direct-current service.

It will be noted that with the connection shown current is flowing through only half of the windings



How three motors were dried out at one time.

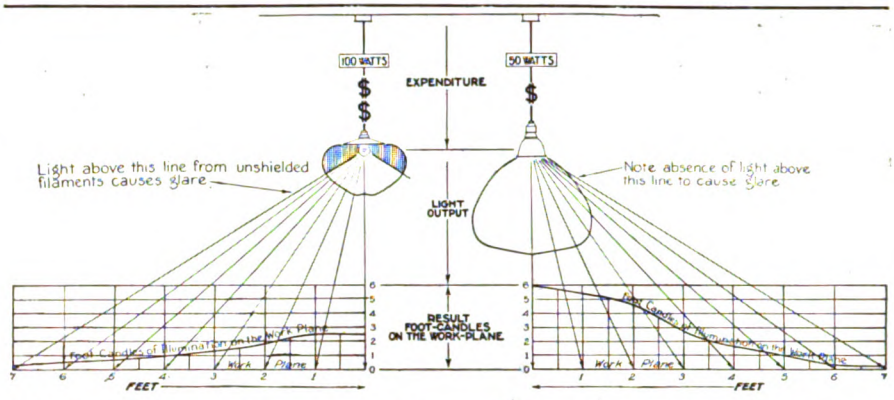
The motors were four-parallel, star-connected as shown at *A*. Current was passed through only two of the four circuits in each phase as shown at *B*.

of each machine, but as the winding is evenly distributed over the stator the whole winding soon reaches an even temperature. The entire time of disconnecting and reconnecting the three motors was approximately six hours.

With this arrangement about 11 volts were impressed on each section of the winding or 4.3 per cent of operating voltage. The current was (250÷3) or 83 1/3 amp. through each section or 120 per cent of rated current.

Of course if this percentage of current had been passed through all of the coils on the machine instead of half of them, the temperature would have been higher. In such a case the current would have to be less, say, only about 100 per cent, in each section to give a temperature satisfactory for drying. With rated current the heating would be above normal because the ventilation would be much less when the machine is standing still.

Newark, N. J. E. C. SOARES.



This diagram shows how better lighting at less cost can be secured by a correct use of lamp and reflector.

The illustration at the right indicates the increase in actual foot-candles of light on the work by the use of a deep-bowl, porcelain-enameled reflector containing a rugged 50-watt mill-type lamp over the light obtained from a 32-cp., 100-watt carbon lamp in a 10-in. flat cone reflector. The saving in energy is also apparent from the sizes of the lamps.

Importance of Rugged Lamps and Proper Reflectors Localized in Mill Lighting

RECENTLY INDUSTRIAL ENGINEER has described a number of ingenious methods for mounting lamps and reflectors in steel mills and in other places where there is considerable vibration. Unfortunately, the desire for a rugged light source not infrequently leads to the recommendation and use of a lamp and reflector combination which is not only uneconomical, but actually harmful because of the glare resulting from an insufficient shielding angle. In the past many mills have used, and are still using, 32-cp. carbon lamps, equipped with flat cone reflectors wherever so-called local lamps are required.

Rugged Lamps.—It is believed that a number of maintenance engineers and plant electricians have not investigated the new type Mazda mill-type lamp built especially for rugged service. The lamp—available only in the 25 and 50-watt sizes for 110-125-volt lighting circuits, and in the 50-watt size for 220-250-volt circuits—because of its low wattage, is best adapted for use on extension cords and local lighting devices which are used to furnish illumination only over a restricted area or for a machine.

The filament of this lamp is coiled and is mounted on a short, sturdy support. It is inherently rugged because of the special ring-type construction.

The lamp bulbs are of a short, sturdy construction and are tipless—a feature which is very important for extension cord and local lighting service, where the lamps are handled to a considerable extent. It must be remembered, however, that the ruggedness of mill-type lamps is obtained at a slight sacrifice of lamp efficiency and that lamps of the regular construction should be used wherever the conditions of service do not cause an excessive breakage.

Expenditure.—The 50-watt Mazda mill-type lamps are rated at 420 lumens. This is 27 per cent more light than is given by the 32-cp. carbon lamps, which require twice the expenditure of wattage. The 30 cents spent for a 32-cp. carbon lamp is of minor importance if it eats up $4 worth of 4-cent current to keep it burning for 1,000 hours. The more economical lamp in the long run is the mill-type lamp, which costs 10 cents more but consumes only $2 worth of current in the same time—and supplies twice the light on the work when used in the proper reflector.

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Reflector Efficiency — Light and Foot-Candles.—It is important, in the first place, to use a lamp which produces a relatively large amount of light from the energy it consumes and, in the second place, to use a reflecting device which will permit the light so obtained to be fully utilized. The accompanying diagram shows that it is possible to obtain more actual foot-candles of light on the work by the use of a deep-bowl porcelain-enameled reflector containing a rugged 50-watt Mazda mill-type lamp, than can be obtained from the 32-cp., 100-watt carbon lamp in the 10-in. flat cone. The former, the deep bowl, is scientifically designed to direct the light to the work where it is needed, while the flat cone merely serves in a small way as a substitute for a bit of flat ceiling above the lamp. The effective distribution of light shown for the deep-bowl reflector and the 50-watt Mazda mill-type lamp is obtained by using the standard 7½-in. deep bowl designed for use with the standard 50-watt vacuum lamps, fitted with a standard 1⅜-in. socket extension plug to bring the filament of the mill-type lamp into proper position in the reflector. With the filament of the mill-type lamp in this position, the distribution of light and the reflector efficiency are approximately the same as are obtained when a regular vacuum 50-watt lamp is used without the socket extension. Reflector manufacturers design their equipment for a definite filament position and the user who disregards this fact fails to get the best results from his lighting.

Glare.—To the disadvantage of low efficiency characteristic of the carbon lamp and flat tin-cone shade must be added the handicap of glare, which is very evident because of the improper shielding angle. With the reflectors in the position shown in the diagram, for example, 4 ft. above the bed of a lathe used for trimming rolls, practically all of the light emitted in the angles above the 60-deg. line, indicated by the shaded portion in the distribution curve, will cause glare because the light comes directly into the worker's eyes from the unshielded filament. At all times light in the direction of the eye should be diffused. A 32-cp. carbon lamp in a flat tin-cone reflector at the height shown would be prohibited by a number of recent state lighting codes because of the glare.

To sum up: (1) Ruggedness can be obtained by using the recently standardized Mazda mill-type lamps; (2) the greatest utilization, or foot-candles of light on the work, is obtained by using properly designed reflectors in connection with the lamp; (3) mill-type lamps, having a short light-center-length, can be efficiently used in any reflector properly designed for regular 50-watt vacuum lamps by using a standard 1⅜-in. socket extension; (4) harmful glare is easily minimized by using reflectors with a sufficient shielding angle. JAMES M. KETCH.

Engineering Department,
National Lamp Works of G. E. Co.,
Cleveland, Ohio.

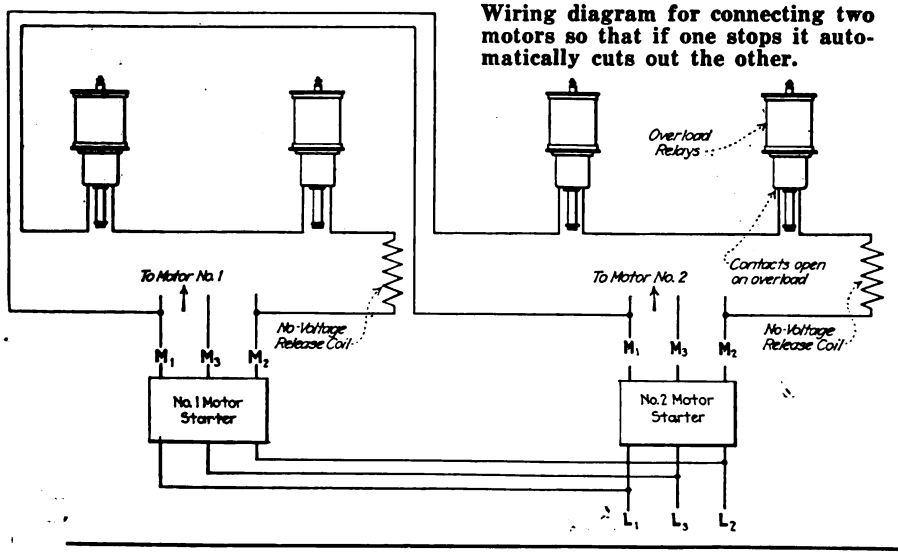
Automatically Stopping First of Two Motors When Second Stops

WHEN one machine feeds another considerable trouble is likely to result unless some provision is made to stop the first automatically in case the second should get out of order and stop. For example, an ice crusher and a conveyor operated in combination often went out of commission because the conveyor would for some reason become choked and the overload relays stop its motor. Unless stopped in time, the crusher would continue to fill the conveyor pit until the lower end of the chain and buckets was practically in a solid cake of ice. A new man would invariably fail to open the crusher switch soon enough to prevent this. His next move would be to throw in the switch of the conveyor which usually resulted in broken chains and buckets bent out of shape or torn off, or if we were lucky, only the chains off the sprocket. In any case it gave a mean job for repairs.

To overcome this difficulty an idea was used which may be an old one with others, but was tried out at our plant for the first time. This plan was to connect the motors so that if one motor should stop the other would automatically stop also. The accompanying sketch shows how the connections were made. It must be remembered that this scheme is good only where both motors are always used together if overload and no-voltage protection is wanted for either or both motors as individual machines.

The starters used in this case were the Crocker-Wheeler AX starters with overload relays and no-voltage release coils. The sketch shows the no-volt release coil circuits, which alone are changed. VICTOR ORTH.

Gardenville, N. Y.



Wiring diagram for connecting two motors so that if one stops it automatically cuts out the other.

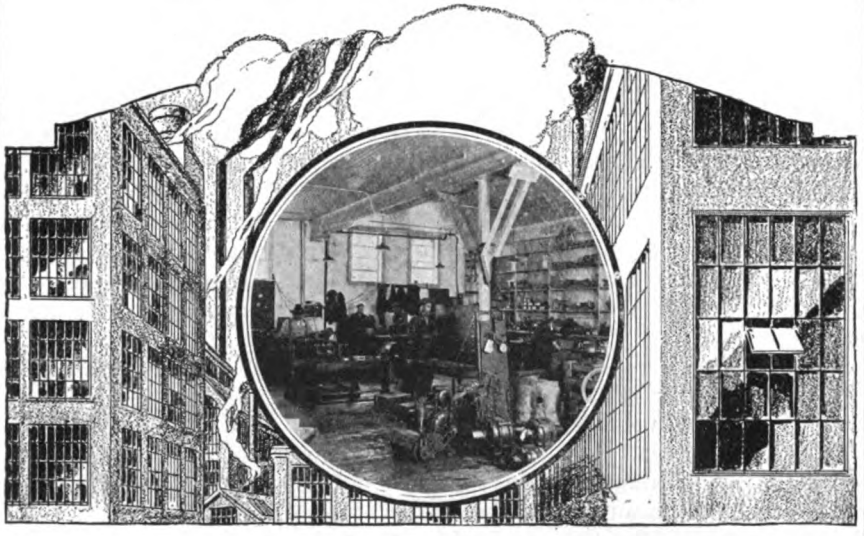
Choosing Proper Type Condulet When Wiring for Motor

IN THE August issue of INDUSTRIAL ENGINEER there is shown on page 368 a good and a bad example of wiring old-type motors. These motors have exposed terminals on both sides of the frame, which naturally renders it difficult to make an installation which is comparable in neatness and general appearance with installations of modern motors. In the good example mentioned above the illustration shows that two type A condulets were used. I do not wish to appear critical, but it seems to me that a type B or type E condulet would have been preferable in this case.

Topeka, Kan. C. DICKERSON.

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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welocme.

Heating of Induction Motor Due to Grounded Wedges

AN INDUCTION motor that ran very hot, although not fully loaded, came to the writer's attention some time ago. This was a 15-hp. motor which drove a pump in a chemical plant. It had replaced a 10-hp. motor which had carried the load satisfactorily without heating. When the 10-hp. motor broke down it was decided to put in the 15-hp. motor temporarily. This motor was a squirrel-cage machine rated at 15 hp., three phases, twenty-five cycles, four poles, 720 r.p.m., 40 deg. rise at constant duty. It was one of the company's spare motors and was being used for temporary service on an elevator, in intermittent duty, where it worked satisfactorily. But when it was connected to the pump it would run for only about three or four hours when it would become so hot that it had to be shut down. The motor was tested for grounds, shorted coils, loose bars, torque, speed, and so on, and found perfect but it would still heat up after a three-hour run.

This was a puzzle but finally investigation revealed the fact that the dust in the plant was a mixture of carbon and other conducting materials, and that a thick sticky layer was soon formed on any stationary object. Also, this motor had in the stator slots metal wedges of the two-piece type, i. e., iron hair pin and brass center pin, the wedge being insulated from the stator laminations by a 0.010-in. fishpaper cell. Upon testing these wedges it was found that every wedge was grounded. The dust formed a bridge over the insulation entirely across the slot, thus short circuiting the tooth laminations and forming a path for eddy currents. These eddy currents in the rotor caused the heating. This was borne out by the fact that on a test run, only the stator iron got hot while the winding remained cool. This trouble was not experienced when the motor was used for intermittent duty, as it was not in service long enough at one time for eddy currents to heat up the iron.

The manufacturers of the motor were then consulted and agreed to furnish a new type of metal wedge that had been developed which they said would clear the trouble and would still retain the advantages of a metal wedge.

The motor was sent in to the shop where it was thoroughly cleaned and the old wedges were removed. The new wedge resembled a fiber wedge in shape but was composed of micarta with iron wire imbedded in it. The micarta completely surrounded the iron so that there was no chance for grounding the wedges.

After the wedges were put in, the motor winding was given three dips in Sterling varnish and baked fourteen hours after each dip. Then it was sprayed with an air-dry varnish. When put into service the motor operated satisfactorily and has continued to do so up to the present time, over eighteen months.

Detroit, Mich. A. C. ROE.

Data Which Should Be Taken Before Stripping a Motor

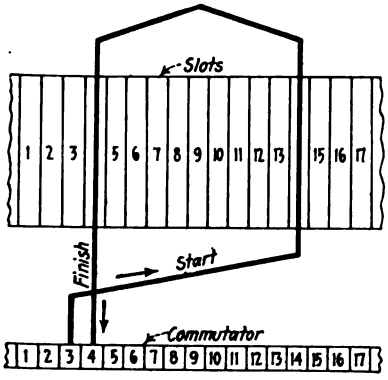
BEFORE stripping a motor that has to be rewound, certain information should always be put down on paper. No matter how familiar one may think he is with a motor before it is stripped, he may forget some important connection before the time when he has to reconnect it. Such a job is often held up while waiting for insulation, wire, coils, and so on, or some other more important job may require the attention of the repair man.

Card which holds complete information on a motor.

MOTOR NO. 16 LOCATION Wood Shop #1 Planer.
H. P. 40 TYPE M. A. MFR. Westinghouse.
FORM Open STYLE #151786 FRAME 334 A.
PHASE 2. CYCLE 60 R.P.M. 860
VOLTS 440 AMPS. 45.
BEARINGS 2 Ring.
CONNECTION Belt Drive. CONDITION A.1.
PURCHASED 1911 INST. 11 - (Wood 19)
WINDING Formed & Coils, Open Slots. Squirrel Cage rotor.
SERIAL NO. 934059.
STARTER Westinghouse Air Break FUSE 75.
TESTS 3/28/14 FIELD LOAD 8½ H.P.
5/7/19 Variable " 22 H.P.

DATE	REPAIRS	COST	CHANGED
7/13/19	2 New Bearings	5 00	19 FROM East Line TO Planer

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The drawings shown here are samples taken from an alternating-current and a direct-current motor. I usually make a rough chart on the order of these drawings, and then at my leisure draw a better one using colored ink for the different phases. I keep these charts in a loose-leaf ledger. Probably the most important point to bring out in a chart is whether the connection should be made from the front or the back of a coil. In addition to the drawings I write down data such as that listed in the caption underneath the drawings on this page.

When rewinding the motor if sufficient information is not contained on these drawings I consult the card index of all motors, which we keep in file. A copy of one of these cards is shown herewith. N. S. DAVIS.

Batavia, N. Y.

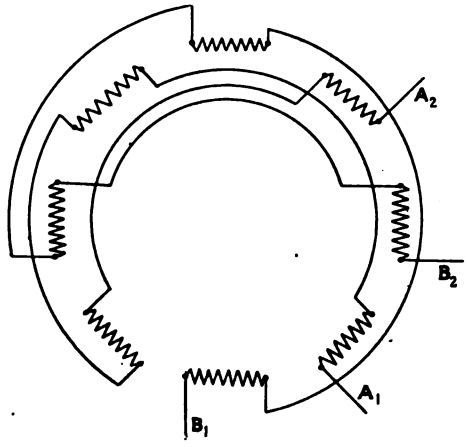
Composition of Hard-Drawn Rods Used for Arc-Welding

HARD drawn rod electrodes conforming to one or the other of the specifications shown in the table have been standardized by a leading industrial concern on the Pacific Coast. These rods are used on mild steel, structural shapes, plates, bars, low-carbon forgings, and castings. For arc-welding on high-carbon and alloy steels special electrodes are used. On high-carbon steels where the weld is not to be machined, but a hard wearing surface is the principal consideration, electrodes containing 0.95 per cent carbon are used. If the welds must possess unusual density and uniformity in order to secure a high polish or be easily worked, covered nickel-steel electrodes are recommended for use on high-carbon steel.

San Jose, Cal. D. N. LOUIS.

COMPOSITION OF HARD-DRAWN RODS FOR ARC-WELDING

	A Per Cent	B Per Cent
Carbon	not over 0.06	0.13-0.18
Manganese	not over 0.15	0.40-0.60
Phosphorus	not over 0.04	not over 0.04
Sulphur	not over 0.04	not over 0.04
Silicon	not over 0.08	not over 0.06



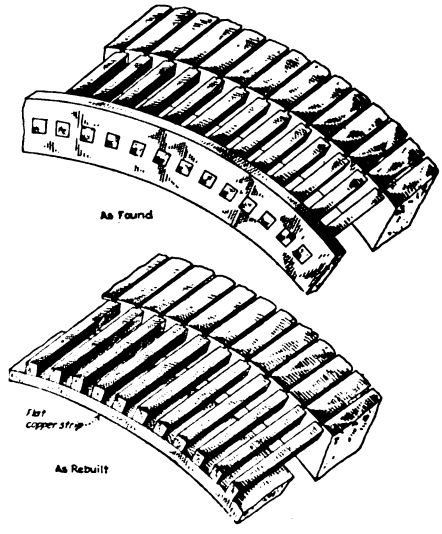
Diagrams drawn before stripping motors.

At the left is a drawing for a d.c. motor; at the right, one for an a.c. motor. In addition such information as the following should be recorded: For the a.c. motor—Westinghouse, 2 hp., two-phase, 60 cycle, 1700 r.p.m., twenty-four 68-turn coils, No. 18 d.c.c. wire, three coils to a pole, 1 coil to a slot, throw 1-and-10. For the d.c. motor—Sprague, 6 hp., 600 r.p.m., d.c., 240 volts, 26.7 amp., twenty-seven coils, thirty turns, No. 22 d.c.c.

Rebuilding Rotor End-Rings Reduces Trouble

MUCH of the trouble caused by induction-motor rotor bars becoming unsoldered from the end rings has been eliminated from the older motors of the Old Dominion Copper Company, by a change in the end-ring construction. Originally the end-ring construction was as shown in one of the illustrations. The bars projected through the end rings. When such motors are brought into the shop for repairs these end rings are removed and a copper band is soldered in place as shown underneath the bars. In some cases rivets are placed through the bars and ring to increase the mechanical strength. The ring consists of a flat copper strip, mitered and silver-soldered. STEPHEN TILLMAN.

Chief Electrician,
Old Dominion Copper Company,
Globe, Ariz.



The old end rings were removed and a copper band silver-soldered beneath the bars.

Low-Resistance End Ring Reduces Motor Speed

UPON renewing the bars and end rings of a 100-hp., 2,200-volt, three-phase motor at the works of the Union Pacific Coal Company, we found that the motor would not run above approximately half speed at no load. The motor ran hot and threw fire from the rotor. Examination showed that several rotor bars were broken at the end ring, so it was decided to renew the rotor bars and end ring as the only method of making a first-class repair job. The proper size of rectangular copper for the rotor bars was not available; so they were made from 4/0 round copper wire and hammered to size. Although the original end ring was of different shape and material, it was assumed that the resistance in both cases would be the same, but this could not be verified, owing to lack of proper facilities for making refined measurements. The bars were double riveted at each end and soldered and the work considered first class. Upon testing out the motor it was found to take excessive current with 1,500 volts applied at the terminals and finally damaged the auto-transformer coils in the starter. A starter capable of starting a 500-hp. motor was provided, but again the motor took excessive current and accelerated to only 900 r.p.m., instead of to 1,800 r.p.m., its rated speed. Applying the full rating of 2,200 volts failed to cause any increase in speed.

When the manufacturer was consulted it was learned that the end ring contained too much copper and we were advised to reduce the cross-section one-half. After this was done the motor came up to normal speed. The trouble was caused by the assumption that the resistance of a ¼ by 2-in. copper bar was the same as that of a 1-in. by 1-in. alloy ring.

Chief Electrician, D. C. MCKEEHAN.
The Union Pacific Coal Co.,
Rock Springs, Wyo.

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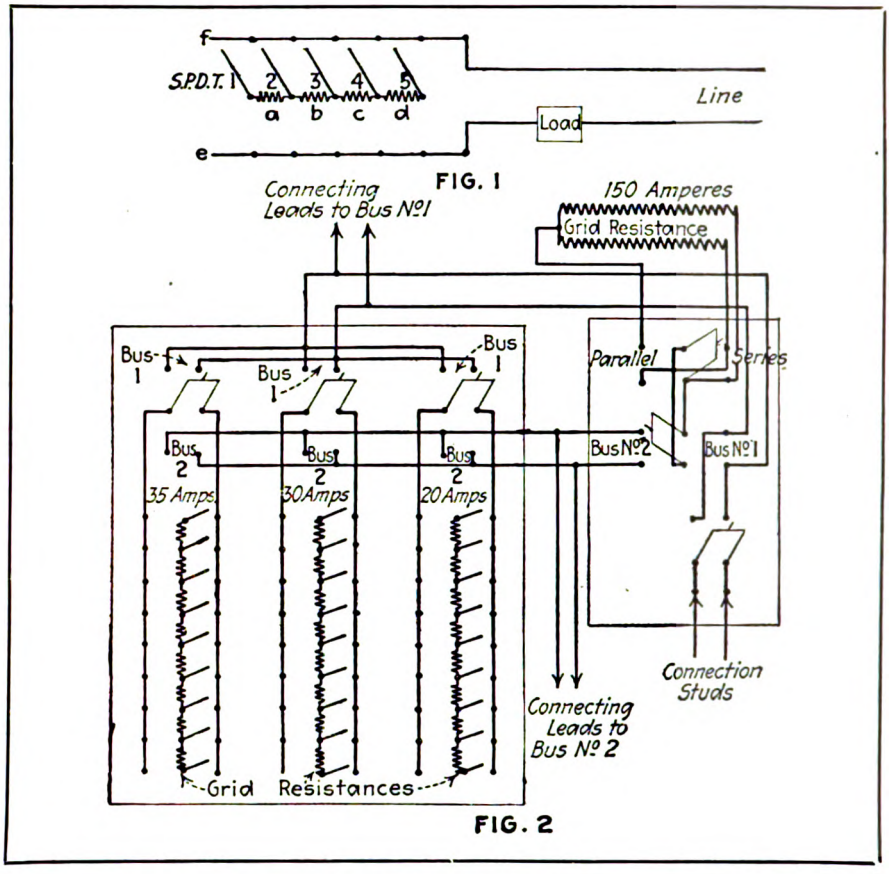
A Portable Outfit With Simple Grid Connections to Give Wide Range of Resistance

BY USE of single-pole, double-throw switches connected as shown in the accompanying diagram, a wide range of resistance is obtained in the portable and stationary resistance units employed in an Eastern industrial shop. The principle of this method of connecting is shown in Fig. 1, where *a*, *b*, *c*, and *d* are resistance units connected by single-pole, double-throw switches to either *e* or *f*. The maximum resistance obtainable is the sum of *a*, *b*, *c*, *d*, the current being limited to that allowable for one of the sections. To obtain this maximum resistance switch No. 1 is thrown over to *e*, switch No. 5 is thrown to *f*, and the other switches are left open. The minimum resistance will be one-quarter of the resistance of any section (provided they are all equal), and with this condition the maximum current will be four times the maximum current allowable for any one section. This condition is obtained by throwing switches 1, 3 and 5 to the left, 2 and 4 to the right. Various steps can be obtained between the maximum and minimum values.

Three resistance tables connected in this manner have been mounted on wheels, as shown at right, so that they can be conveniently moved from one place to another. Each of these tables is made up of twelve resistance sections, the resistance of each section being 0.5 ohm, 0.75 ohm and 1 ohm, and the carrying capacity of each section being 35 amp., 25 amp. and 15 amp., respectively, for the three cables.

A permanently mounted set of grids using the same method of connection has been made up to give a range of 2.5 amp. to 830 amp. at 230 volts. This method of switching is not confined to large resistances; it has been found very useful also in making up smaller rheostats. By mounting on wheels as shown, it can be used more conveniently in any part of the laboratory.

Newark, N. J. EUSTACE C. SOARES.



This rheostat table may be rolled about the laboratory and in this way is made more convenient for general testing.

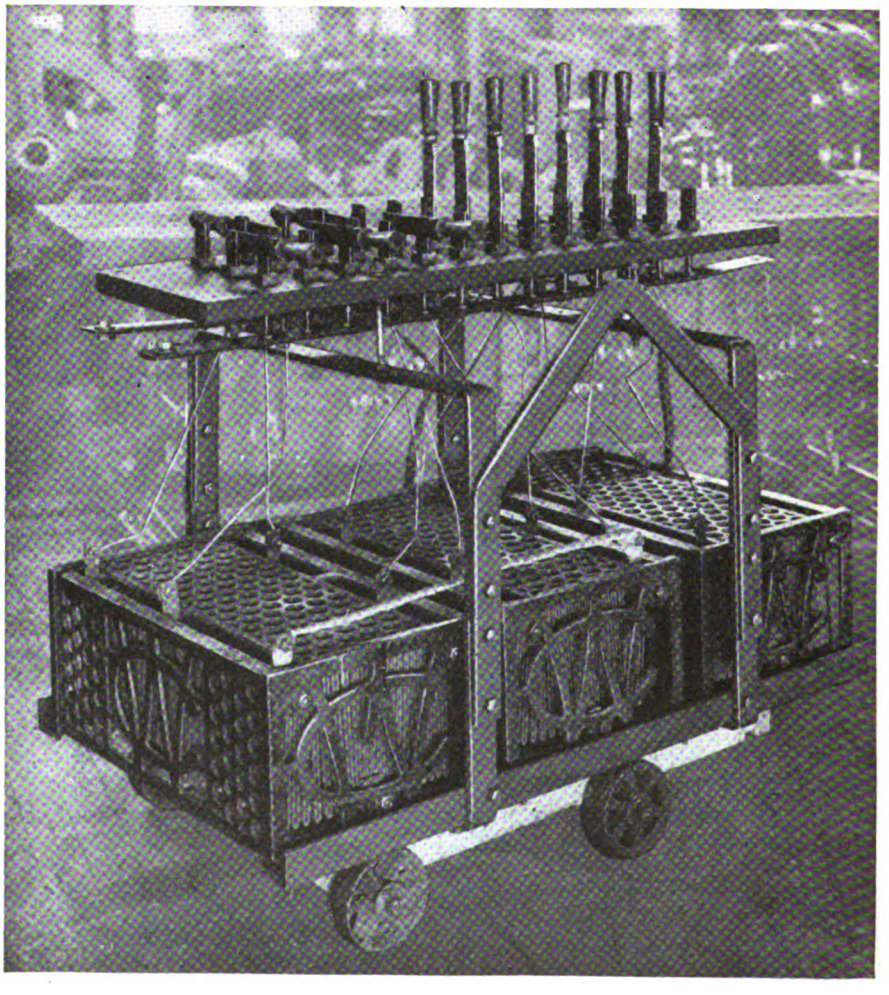


Fig. 1—Scheme of connections for obtaining a variable resistance for test work.

Fig. 2—Adjustable rheostats which give wide range of resistance for the number of resistance units employed.

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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Robbing a Job of Its Disagreeable Features by Doing It Mechanically

ON JOBS which are disagreeable because of the conditions surrounding the work, such as paint or varnish dipping, cleaning and other similar tasks where the operator is likely to have paint or cleaning solution splashed on him, carriers have been installed to good advantage. How these disagreeable features of one paint-dipping job are eliminated is shown in the accompanying illustration. Here the parts to be dipped are hung on a special carrier riding on a double tramrail and carried to the dipping vats. By manipulating the two pear-shaped handles, a section of this tramrail is lowered until the parts are immersed in the paint. They are then raised by the motor operating this section of the elevator and pushed on to the right over the dripping section. The parts, still on this tramrail carrier, then go on to and through the drying ovens.

The parts are thus placed on the carrier before they are dipped and are not touched again until after they are dry, so that the men do not come in contact with the sticky paint. This equipment was manufactured and installed by the Cleveland Crane and Engineering Company, Wickliffe, Ohio.

The operator can perform a disagreeable task and still keep his hands clean.

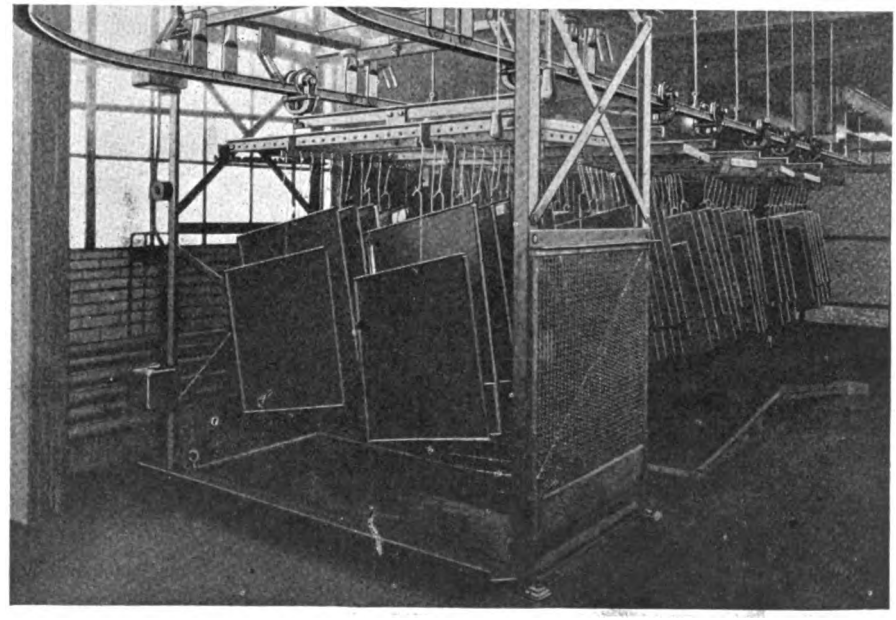
It is difficult to get men, when labor is scarce, to perform dipping jobs and other similar tasks where they are spotted with paint which ruins their clothes and gets onto their hands and faces and even into their hair. With equipment such as this, it is not necessary to touch the parts when they are wet.

Moving Hacksaw to Work Eliminates Double Handling of Heavy Steel Bars

SOMETIMES it is easier to bring the machine to the work than to take the work to the machine. This is a common practice with many small portable tools and with some large special machines. However, one would hardly expect that such a tool as the power hacksaw would be moved from job to job instead of taking the work to the machine. Nevertheless, this is actually done at the plant of The Louis Allis Company, Milwaukee, Wis.

Here a power hacksaw is mounted on the platform of a power-driven portable elevator or tiering machine made by the Economy Engineering Company, Chicago, Ill. The platform carrying the hacksaw can be raised or lowered as desired. This company previously removed heavy steel bars which were used for making the armature shafts from the stock racks, trucked them to the machine shop, cut them into desired lengths, returned these lengths and the uncut stock to the storeroom and made a record of the operation. Later, when the foreman in the armature department got an order for armatures those same shafts were removed and trucked to the armature department. This required a large amount of extra handling of heavy bars.

Since the hacksaw has been made portable, the procedure is: The foreman orders a definite number of pieces of shafting for armatures direct from the storeroom. The storeroom man elevates the hacksaw, on the portable-elevator platform, to the proper size of shafting, cuts the desired number of lengths, without removing the long length of shafting from the racks, and delivers them direct to the armature department. This eliminates the delay, annoyance and hard work of taking the stock to the saw in the machine shop and of returning the unused portion to the storeroom. On large bar stock the labor and time saved would be considerable. It also simplifies the stockroom book work necessary.



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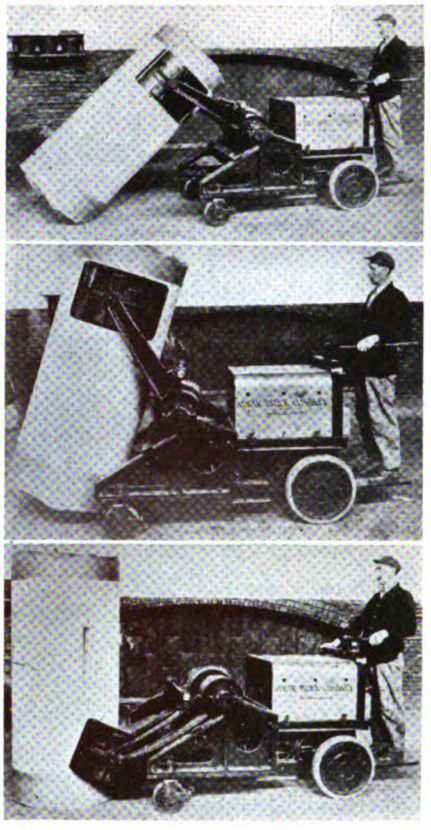
Saving $21,000 a Year With a Special Electric Truck For Handling Paper Rolls

ONE OF the principal features of material-handling equipment has been the design and construction of special machines for special purposes. One example of this is the special electric lift truck for handling rolls of paper as shown in the three accompanying illustrations. Several of these trucks are in use at the different plants of one large paper company. Before installing these trucks the large 72-in. rolls of paper were handled on a 24-hour-a-day basis by seven men per shift. These seven men were employed for finishing, up-ending and trucking. Of this gang five men were required to up-end the roll.

Since this truck has been adopted only two men and one truck are required per shift. Both men are finishers; one is engaged in finishing and driving the truck to the shipping department; the other in finishing and heading the roll. In this way an initial saving of five men per shift has been effected, which in dollars and cents, on a 300-day annual basis, amounts to over $21,000, or several times the original cost of the truck.

There is also a material saving in the time required to handle and carry the roll, to say nothing of having made it much easier on the men. The truck can be used for either lifting the roll from a horizontal position or from a vertical position. One of the distinctive features of the truck is the fact that when the lifting hands come together on the roll with sufficient pressure to lift it, the lifting mechanism automatically elevates the roll without exerting a crushing pressure. The speed adjustment of the truck is so regulated that the truck can be maneuvered up to a roll without breaking the edge of the roll while lifting.

The truck was installed by the Cowan Truck Company, Holyoke, Mass., and is equipped with General Electric motors, Exide batteries, Brown - Lipe - Chapin differential, Alemite system of lubrication throughout, and Cutler - Hammer controller.



Special electric storage battery truck for handling rolls of paper, which takes the place of 15 men.

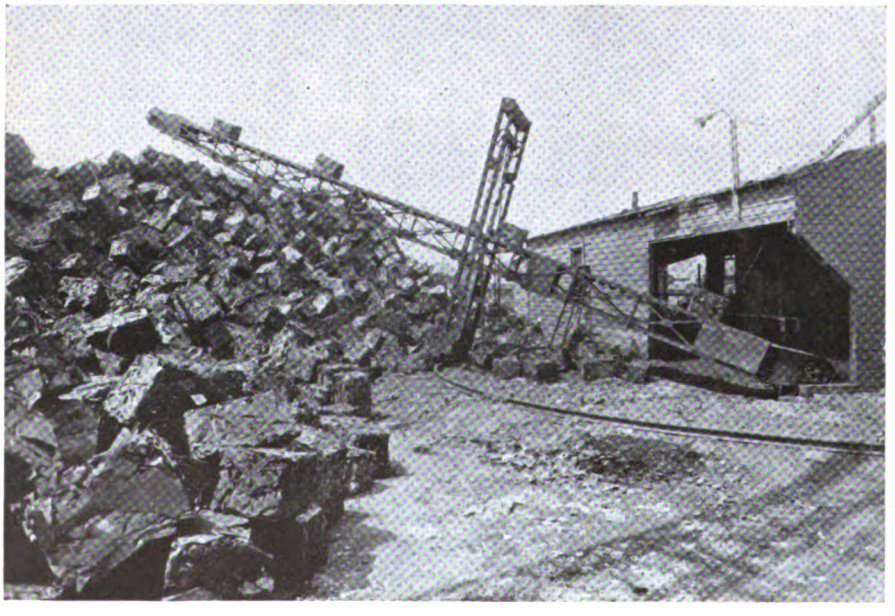
This truck will pick up a 72-in. roll of paper when it is lying down or standing up, carry it to its destination and stand it up or lay it down without damage to the roll. In one paper mill the installation of this truck saved over $21,000 a year by eliminating five men per shift in a plant operating three shifts per day.

How a Conveyor Reduces the Accident Hazard When Piling Rusty Scrap

THE SPECIAL piling conveyor, shown in the accompanying illustration, is used for piling the bales of scrap directly from the baling machine into the storage pile where they are later loaded into cars for shipment. These bales are not only heavy, but are dangerous to handle by hand due to the many sharp and often rusty edges. A conveyor of this type can pile them over a semi-circular area, due to the circular track upon which it is supported and travels.

Many jobs similar to this are serious accident hazards. One of the best methods of making them safe is to do them mechanically. Men in gangs are a hazard to each other; if one man "lets go" of a heavy lift prematurely, the other men are liable to be hurt. However, the man operating a conveyor like this has only himself to look out for and so risks less chance of injury. One of the usual results from the installation of labor-saving equipment has been a decrease in number of accidents.

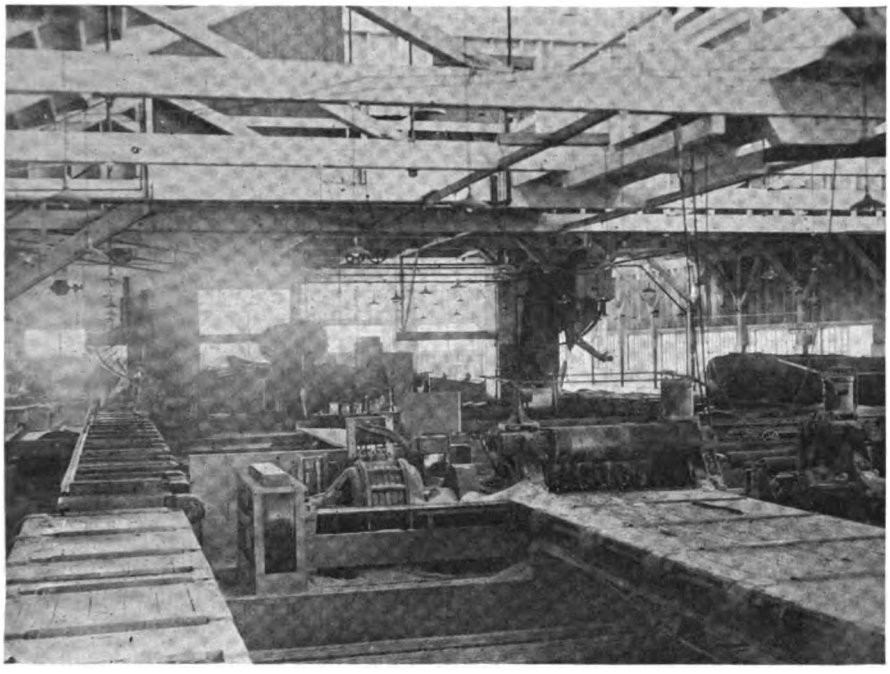
A similar type of conveyor is also used for unloading coal, sand and other loose materials. Gondola cars are dumped into a hopper feeding down into a conveyor of this type which discharges onto a circular pile in much the same way. This not only eliminates the large force of labor which would be required if it were done by man-power, but it also enables the coal or other material to be piled over a larger area and much higher than would be possible with wheelbarrows.



The accident hazard would be very great if men piled these bales of metal scrap. This conveyor is not affected by scratches from rusty metal.

Work like this is too heavy and hazardous and if men can get other jobs it is difficult to keep them on such tasks. Many other "back-breaking and thumb-smashing" jobs can be simplified as easily by mechanical methods and at the same time reduce the cost of the operation.

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Sawdust and shavings make work for the maintenance department in lumber mills.
A motor-driven edger is shown in the left foreground of the illustration.

Maintenance Analysis

(*Continued from page* 51)

One sheet is thus sufficient for a month, or four inspections. If a motor and its control are found to be in perfect condition the inspector puts an O. K. opposite the motor number, in the proper date column. If the motor is defective in any way, the nature of the trouble is noted in the same manner. There is thus afforded a complete record of all inspections made, with the results.

In one of the large packing plants where a large number of motors are operated under very severe conditions, and the failure of a motor may occasion a good deal of loss and delay, a different plan is in force. The entire plant is divided into four sections and each section is put in charge of an inspector who is held strictly responsible for the continuous operation of the motors in his section. He is not required to make reports and is held to no definite routine, but can inspect a motor or other equipment three times a day or once a week, as he considers necessary. When a motor fails, a written report showing the cause of the failure must be given to the chief electrician. If the trouble was not due to neglect the inspector is absolved from all blame. If the failure was due to neglect or other preventable cause, which happens very rarely, the inspector is reprimanded or otherwise disciplined.

Although this method of handling inspection work may not be ideal in all respects it has, under proper supervision, worked out very successfully in this and a number of other plants where continuity of motor service is highly important. Perhaps one reason for this success is that it allows the inspector to use his judgment and initiative and put the emphasis on his work in the proper place, something that a hard-and-fast schedule may not permit. He can come closer to estimating the effects of natural wear and tear than anyone else in the works for, like the family doctor, he knows the ailments of his regular patients.

While it may not be necessary in all cases to have a written report of every inspection, when this shows that the equipment is in good condition, it is very essential that a complete record be kept of all defects and failures which develop, together with the nature and cost of the repairs. In too many instances the fact is overlooked that records such as these are the vital statistics of maintenance work. To attempt to carry it on without these records would be like trying to conduct a business without a set of books.

Records of Equipment Failures Should Be Carefully Studied and Analyzed

As Arthur J. Whitcomb pointed out on page 377 of the August issue of INDUSTRIAL ENGINEER, an analysis of the records of motor failures is of interest: First, to the motor inspector so that he may know what parts to watch closest; second, to the storekeeper in order that he may keep an adequate supply of the parts most frequently needed; third, to the electric repair shop so that there may be kept available facilities for the repair of motors or equipment on which failures occur most often, and fourth, to the electrical superintendent in order that he may have a grasp of the number and kinds of failures and may also be able to compare the failures of one period with those of another. Further, careful study and analysis of the records of failures will often disclose in the design or application of equipment inherent weaknesses which might otherwise pass unnoticed. For example, repeated failures of a motor or its control equipment means that something is wrong. These parts are either overloaded or are of the wrong type for the service requirements, or are being neglected. Finding the proper remedy may or may not be a simple matter; in any event, a weak spot has been pointed out.

The value of accurate repair cost records, particularly the cost of making new coils, bearings and other parts, is often overlooked. The repair shop usually turns in a labor-and-material cost for at least the larger jobs, but there is frequently no definite data as to the cost of the coils and other parts which are made in the shop; therefore it is impossible to tell whether these can be bought from the manufacturer more cheaply than they can be made. Except as an emergency measure, when speed of repair is important, there is no economy in spending $10 to make a part which can be bought for $7.50. This is, however, done in many instances and increases the cost of repair work unduly. The only way this condition can be avoided is to find out exactly what it costs to make such parts and then compare these figures with the manufacturer's prices.

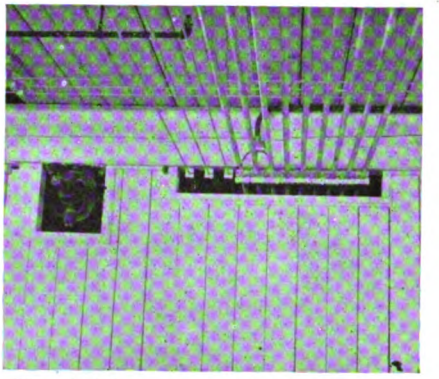
A repair shop operated in connection with the electrical department of an industrial works is just as much of a business enterprise as a commercial repair shop and the same business principles should be applied in its management. Guesswork or inaccurate records will cause loss in the one as surely as in the other.

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The Engineer and Contractor

(*Continued from page* 22)

details of the specifications for the individual jobs would be essential to such a specific interpretation. These are submitted merely as examples of analyses that are useful and essential to the estimator who possesses a fundamental knowledge of trends in costs and the requirements of high standards of construction practice. These photographs illustrate some types of construction that present problems for experienced men and represent good practice from every standpoint. It is usually found advisable and profitable to make and file photographs showing stages of progress of the work. These are useful in connection with instructions to new superintendents and foremen employed by electrical contractors and as illustrations of methods of doing the work when changes or improved methods are to be followed. In such cases they serve to definitely picture the details of the work in the minds of superintendents and foremen and are available to them as references during the progress of the work as well as at the time they are being instructed in regard to it before it starts. Moreover, such a file of photographs serves as valuable silent evidence of the character and quality of workmanship that the electrical contractor is capable of furnishing. They also serve as a basis for settling controversies that may arise out of conflicts in the progress of work that should precede electrical installations and as the basis for extra costs when deviations from the specifications are being considered.



The finish on a job illustrated by these paneled openings is one of the things that add as much to class of workmanship as permanency of construction.





The lower illustration shows how daylight conditions shown in the upper illustration can be approached by good illumination. Cooper-Hewitt lights are used.

Maintenance Work Can be Audited

(*Continued from page* 15)

He has endeavored to explain and give reasons why the electrical storeroom should be under the electrical superintendent, how the electrical storekeeper keeps track of his stock by a perpetual inventory, how he knows when to reorder, his method of giving this information to the electrical superintendent who either approves or disapproves the requisition and thus releases the electrical storekeeper's responsibility in not having the material. Also it is shown how the "Main Storeroom" is enabled to keep a check on the material being requisitioned, how the need for the material is brought to the attention of the general superintendent, the operating vice-president and finally the purchasing agent, who at once orders the material from the manufacturer. So far during the cycle, the inventory card has shown the electrical storekeeper the need for the material and the requisition has rendered an accounting of this need to the electrical superintendent, the main storekeeper, the general superintendent, the operating vice-president and the purchasing agent. The material as received at the "Main Storehouse" and the "Memorandum of Receipts" forms the audit or accounting of this material until it has reached the electrical storeroom and it forms the voucher, after the OK of the electrical storekeeper, to the accounting department so that they may pass the invoices for payment. After the material is used, the "Storehouse Order" forms the means of accounting for why and where the material was used and is the authority for the electrical storekeeper to charge the material off his ledger or inventory card, and likewise for the main storekeeper to charge the value of material used against departments using it. Thus the cycle of purchase and use of materials is finished.

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Maintenance and Operation Bonus

(*Continued from page* 10)

of all other motors in the plant which may be substituted for it. Thus, whenever a breakdown occurs, even though no substitute is in the store room, it is generally possible to pick out a motor from an idle or less essential machine. The 250 motors in the plant from ⅛ to 500 hp. include a surplus of about 10 per cent idle for auxiliary or emergency service. Practically all motors above 25 hp., except the three 100-hp., 440-volt, direct-current motors on the calender mills mentioned, are of 2,300-volt, 60-cycle, 3-phase design. These are all inspected regularly, even the ½-hp. motors.

As several of the departments, such as the *Mill Rooms*, are very dusty from powdered soapstone, the motors and bearings require frequent cleaning and inspection. Because of these conditions it was difficult to keep some of the big bearings, which were fitted for grease lubrication, from heating and burning out, due to the mixing of the dust with the grease. Now these are fitted with sight-feed oil cups which are looked after by the oiler. While they sometimes overfeed and the oil runs out the end of the bearing, they are giving much better satisfaction than the grease cups.

A record is kept of the amount of lubricating oil used over a period of six months which is compared with that of the previous six months. Other similar records of supplies are kept and checked by the maintenance department to see that the consumption does not increase unduly.

Another plan which helps check up on maintenance is used by the maintenance superintendent. The white copy of each maintenance order (Fig. 4) is filed in a folder, after the job is finished, marked with the name of the equipment whether it is a motor or machine. These are gone over periodically to see if any type of repairs are occurring too frequently. When making a repair report, the men often note that only a short time has elapsed since a similar one had been made. This record shows the date and perhaps discloses several similar repairs made within a short time previous. For example, recently we had occasion to check the life of some rawhide pinions on some of the machines. When we could show the manufacturers that one lot of pinions was lasting only from two weeks to a month while other lots were lasting a year or more, it was easy to get them replaced.

Also stuffing boxes on the calenders were blowing out too frequently. This led to installing larger boxes which take more packing and are holding up longer. This record also shows up any bearings or other parts which give so much trouble as to demand special attention. It is an important factor in keeping the maintenance costs low, through aiding in the supervision and checking because maintenance is largely a matter of proper records.

Altogether, the bonus plan works very satisfactorily since it pleases both the foreman and the company. Foremen are rewarded for thinking ahead, because to make the bonus regularly, and some of them earn full third bonus frequently, they have to consider not only doing a first-class job today at a reasonably low cost for a good job, but they also have to consider how the equipment is going to stand up in future bonus periods. The savings which have resulted from this bonus plan were estimated at 5 per cent of the total cost of production for the first year. The larger proportion of this saving was made in the *Production Departments* although the *Maintenance* and *Power Departments* contributed their share, by helping to maintain the equipment in condition for continuous operation.

Better Methods of Handling Materials

(*Continued from page* 47)

types of equipment which are installed. One such case is illustrated in this article where an elevating-platform truck skid is provided with wheels to make it "live" and chains so that it may be handled by the overhead crane. Universal equipment such as this very much increases the mobility of material-handling devices in the plant. Provisions whereby skids are interchangeable between hand-lift trucks and electric-lift trucks are always advisable where both are used in any one plant, for then the hand-lift truck can be used most economically for short movements and for "spotting" and the electric-lift trucks used for longer hauls.

Practically all manufacturers of material handling equipment are working along the one idea of simplicity in operation and reliability. In getting simplicity of operation considerable effort has been placed towards simplifying the control. One example of this is in providing push button or some similar type of remote and safe control for electric hoists.

A great deal of material-handling machinery, particularly that used for handling miscellaneous freight, is of such a nature that the most simple standard electrical equipment meets all conditions satisfactorily. In general the trend seems to be toward higher speeds, increased safety requirements and special construction to reduce maintenance.

Higher speeds mean larger power requirements and more expensive equipment, but there is always the danger of carrying this too far. For example, some operations in the handling of miscellaneous cargo probably always will require a certain amount of manual labor and in general this phase of the operation is the limiting feature. When speeds are carried to a point where the mechanical equipment has idle periods waiting for manual labor to catch up, a part of the capital investment is earning no dividends on account of the speed being higher than necessary.

Decreased maintenance resolves itself into larger wearing surfaces, decreased wheel loads, improved bearings such as ball and roller, more effective methods of keeping oil and grease from the electrical windings of machinery, totally enclosing such equipment as will stand it without overheating and similar improvements.

It is not necessary to spend $50,000 to $100,000 or more to reap benefits in material handling costs. On an expenditure of a few hundred dollars, many companies have made savings which have repaid the cost of the equipment several times within a year. In conclusion, it may be well to say that at any time when reductions in costs and increases in production are being studied, or when it is desired to put production on a more even flow of work, with schedules and a dispatching system to route it through the plant, it is well to investigate all the available methods of handling materials. One or more methods can usually be adapted to the task.

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Trade Literature
You Should Know About

Readers may obtain any of this literature by writing to the address given in the item, mentioning the name and number of the literature and that it was listed in the Industrial Engineer.

Automatic and Electric Furnaces, Ltd., 173-175 Farringdon Road, London, E. C. 1—A 20-page catalog describes several types of Wild-Barfield automatic electric furnaces for the hardening of steel in connection with a magnetic detector which indicates the quenching point. Descriptions of oil and salt tempering baths, "maturing" (aging) ovens, pyrometers and a magnetic sclerometer are also included.

Sprague Electric Works of General Electric Company, 527 West Thirty-fourth Street, New York City—Construction details of Sprague safety type panel board and cabinet, Type T. P. S., are described and illustrated in folder No. 67,901. This equipment is designed for places where busbars and other live parts must be covered, but the fuse plugs left accessible.

Cleveland Armature Works, Inc., 4732 St. Clair Avenue, Cleveland, Ohio—A small folder describes the pedestal and post types of electric grinders and buffers for light work, put out by this company, which have a built-in motor operating at 3,600 r.p.m.

The Electric Motor and Engineering Company, Canton, Ohio—Catalog No. 3 (Section 4) describes the panel boards, switchboards, steel cabinets and other power equipment specialties put out by this company.

Conveyors Corporation of America, 326 West Madison Street, Chicago, Ill.—A series of folders describes the American coal-handling equipment and steam jet ash-handling conveyors put out by this company. Considerable operating and other descriptive information is contained.

Century Electric Company, 1827 Pine Street, St. Louis, Mo.—Repulsion start induction single-phase Type RS motors from ⅛ to 40 hp. are described in Bulletin No. 29. Numerous illustrations show the construction details as well as many industrial applications of this motor.

Gillis & Geoghegan, 537 West Broadway, New York City—Pamphlet No. 190 gives the results of various tests made on the G. & G. telescopic hoists for removing ashes and handling other loads between floors.

Triplex Machine Tool Corporation, 18 East Forty-first Street, New York City—A small folder describes the "Triplex," which it is claimed is a combination of a turning, milling and drilling machine. This machine is claimed to be especially advantageous where a wide variety of very accurate work is to be done, as it in itself has almost complete machine equipment and can do almost any operation on small work.

Lewellen Manufacturing Company, Columbus, Ind.—Catalog No. 15 de-describes the Lewellen variable-speed transmission, which is made in ball-bearing, self-oiling or standard type. The variation in speed in this equipment is obtained by means of a flexible belt passing over two cone pulleys, the diameters of which may be varied. Many of the industrial applications are illustrated.

Thermalene Gas Corporation, Kankakee, Ill.—A booklet describes Thermalene gas for cutting, welding and repair work. This gas is generated as it is used, from portable generators which may be taken directly to the work. The same type of welding and cutting torches are employed as are used in other gas-welding or cutting outfits.

General Electric Company, Schenectady, N. Y.—Bulletin No. 47,002, entitled "Switchboard Panels and Supporting Framework," describes the various types of switchboards under two general classifications: the vertical type and the bench type. This bulletin contains much useful information for the prospective buyers of switchboards.

Wilson Welder and Metals Company, Inc., 2 Rector Street, New York City—Catalog No. 5 describes the Wilson system of "Plastic-Arc" welding. A total of 48 pages are devoted to a description of the welding equipment and to the results which may be obtained. A large number of diagrams show the positioning of different shapes for welding.

Thompson Electric Company, 226 St. Clair Avenue, N. E., Cleveland, Ohio—Catalog B-21, entitled "Lamp Maintenance Equipment," describes the Thompson safety disconnecting hanger which is used for lowering lighting fixtures when cleaning reflectors or replacing lamps, and so eliminates scaffolding or ladders for this work.

The Emerson Electric Manufacturing Company, St. Louis, Mo.—Bulletin No. 3,156 describes the split-phase type of single-phase induction motors of 1/30 to ½ hp. In addition to the characteristics and construction of these motors, dimension diagrams are given for each size.

Condit Electrical Manufacturing Company, Boston 27, Mass.—Types D-18 and D-22 oil switches and circuit breakers are described in bulletins No. 450 and 452. These are rated up to 800 amp., 15,000 volts., or 1,200 amp., 7,500 volts.

McGill Manufacturing Company, Valparaiso, Ind.—A small folder describes the use of wall guards, to be used on stationary sockets, to prevent theft or breakage of electric lights. Six different types are illustrated.

Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa.—A booklet entitled "Synchronous Motors for Ammonia Compressor Drive," sets forth the advantages of electrically driven ice plants and shows photographs of installations in ice making and refrigerating plants, packing houses, and allied industries, particularly the ammonia compressor, and a complete line of synchronous motors that are especially adapted for this work. This line embraces a wide variety of sizes in slow speeds, for coupled or engine type drive and also, in the higher speeds, for belt drive.

Jones, MacNeal and Camp, Warsaw, Ind.—A large folder gives a detailed sectional drawing of the "Power King" electrical portable drill with two speeds, full ball bearing and oversize motors. Numbered arrows point out the special features; the numbers refer to text descriptions.

The Electric Furnace Company, Salem, Ohio—Two circulars describe the use of Baily electric furnaces for melting non-ferrous metals and also the types of electric enameling, annealing and heat treating furnaces which have been installed within the past few years.

Fairbanks, Morse and Company, Chicago, Ill.—Bulletin H-269 describes the type FH Fairbanks-Morse single-phase, ball-bearing, repulsion-start motor. Considerable attention is given to the design and construction as well as to the performance characteristics and adaptations claimed for this particular motor.

Winfield H. Smith, 10-16 Lock Street, Buffalo, N. Y.—Catalog No. 20 lists pulleys, hangers, pillow blocks and other equipment specially adapted to light power transmission machinery. Speed-reducing gears are listed for transmitting from 1/30 to 1½ hp.

Baldor Electric Company, 4351-55 Duncan Avenue, St. Louis, Mo.—A small folder describes Baldor ball-bearing, single-phase, repulsion-induction motors, from 1/6 to 5 hp., operating on 110 or 220 volts, single phase, 60 cycles, at 1,750 r.p.m.

Fred Medart Manufacturing Company, St. Louis, Mo.—Catalog S describes and illustrates the construction and a large number of the arrangements which may be made of the various types of steel shelving for different industrial uses.

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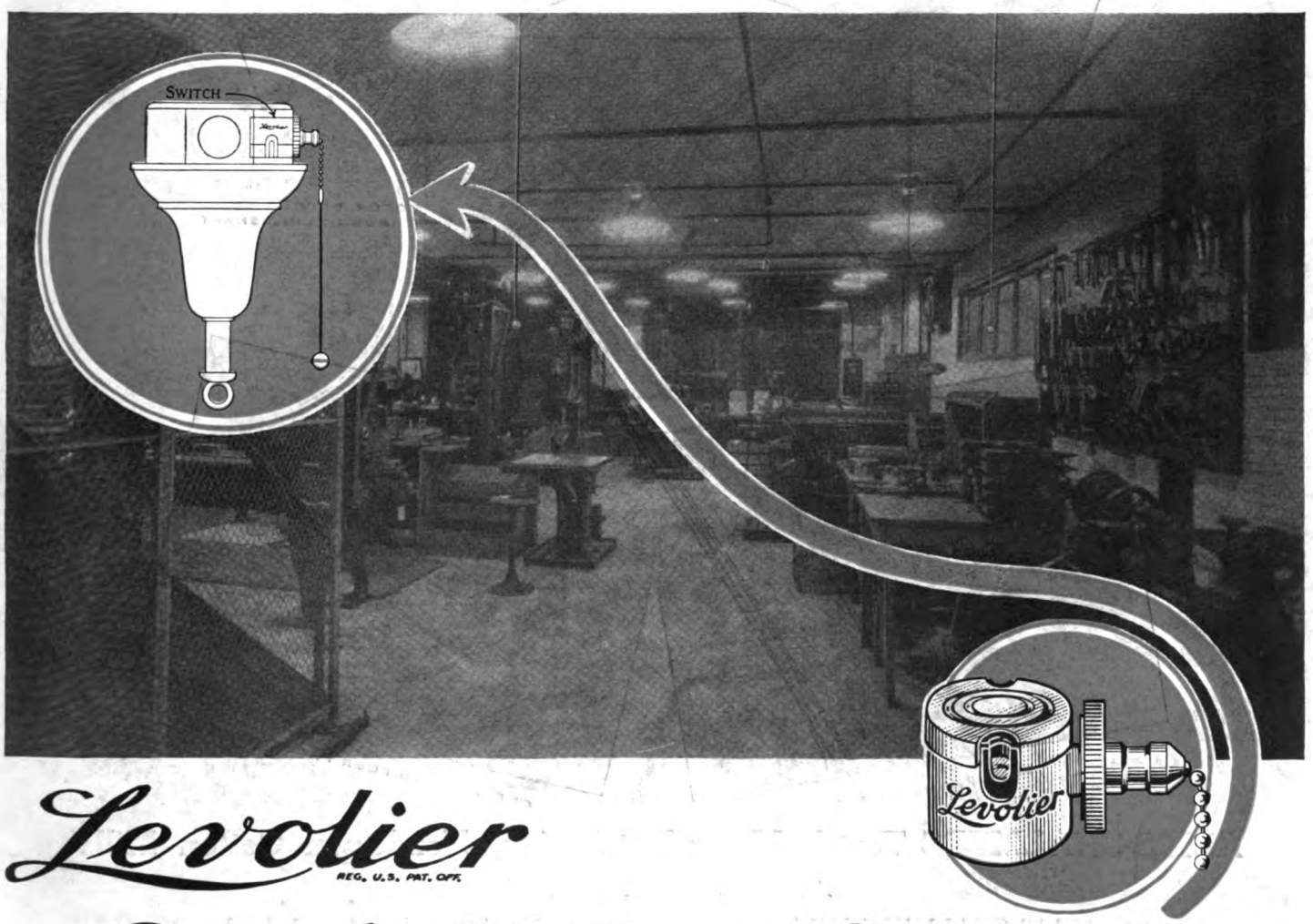
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

February, 1923

McGraw-Hill Co., Inc. Chicago, Ill.



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REG. U.S. PAT. OFF.

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OUT OF THE WAY—RIGIDLY ATTACHED
Quickly Installed on Old or New Work
One Switch for All Exposed Conduit Work
The Same Switch for Many Fixture Installations

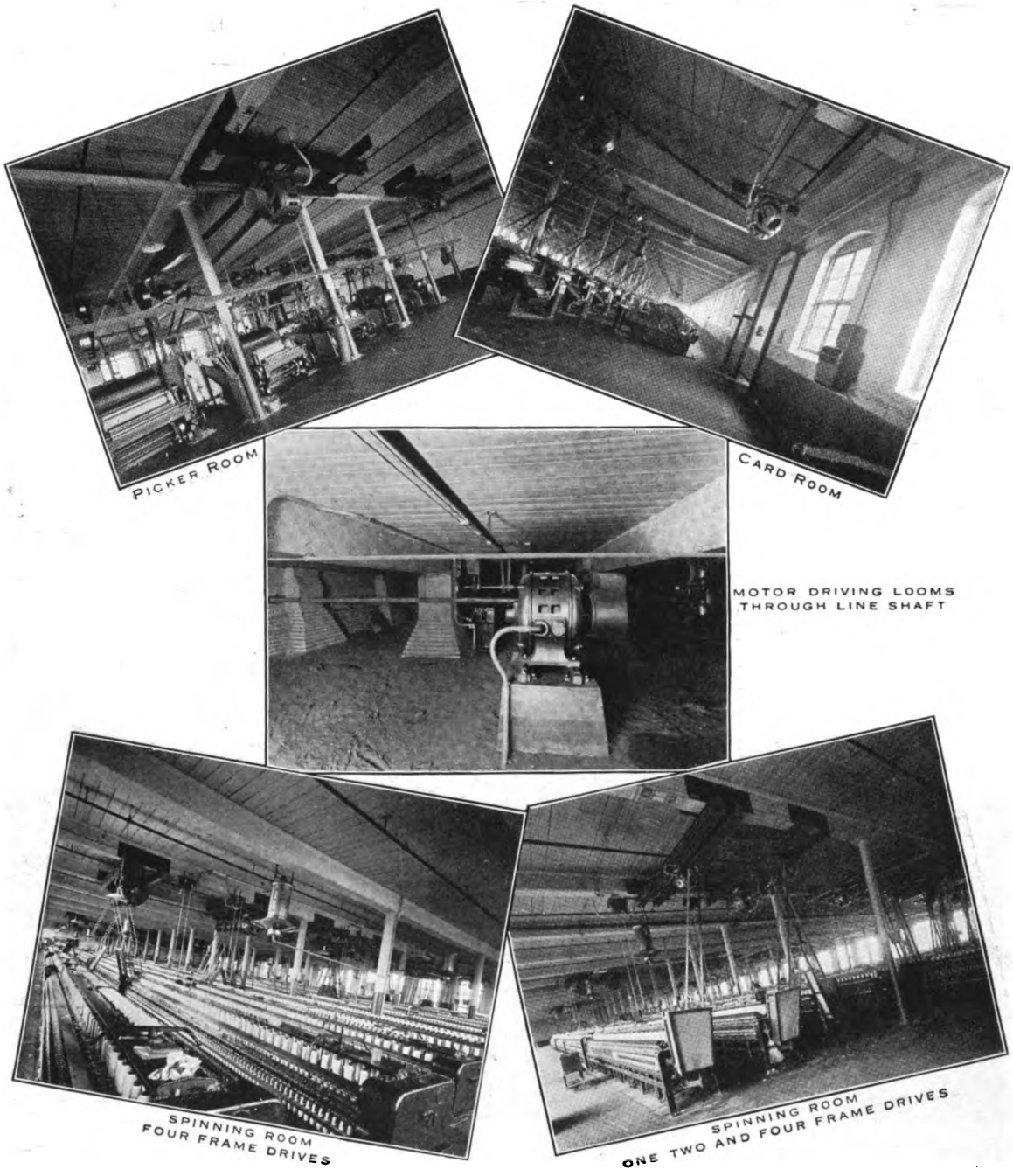
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ALLIS-CHALMERS Textile Motor Installation, Henderson Cotton Mills

An Unsolicited Testimonial

ALLIS-CHALMERS MFG. CO.
Milwaukee, Wis.

Henderson, Ky., Oct. 3, 1922

Dear Sirs:

I wish to say I have had in my charge for the past two years 107 of your motors (Induction Type) ranging from 5 hp. to 75 hp. and have not had any trouble, not even a hot bearing. I want to say they are the best motors I ever saw. My experience heretofore has been with other makes of motors.

Yours very truly,
T. C. WITHERSPOON,
1219 Helm St.

ALLIS-CHALMERS PRODUCTS
Electrical Machinery
Steam Turbines
Steam Engines
Gas and Oil Engines
Hydraulic Turbines
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ALLIS-CHALMERS MANUFACTURING COMPANY

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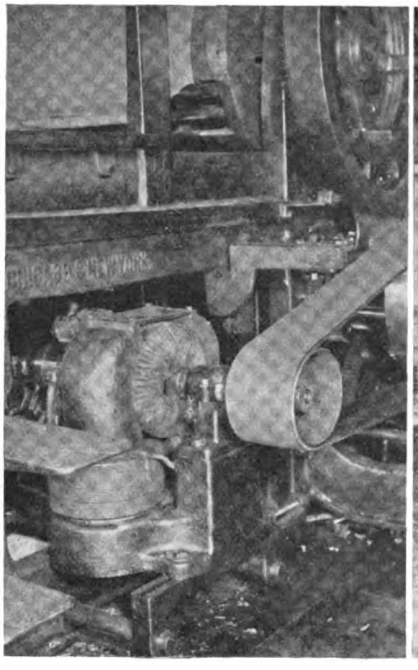
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, February, 1923 *Number 2*

Good Motor Service Is No Accident

It Represents a Combination of Cash and Horse Sense in the Original Guess on What The Motor Must Do





A FEW weeks ago I was browsing around in some Chicago plants that have stood the test of time and competition, just looking for things that are or ought to be. And in the print shop of the Western Newspaper Union at 210 South Des Plaines Street, Chicago, the chief engineer (Mr. Steven Loughman) lead me by two motor drives that certainly got my attention and his apologies before he found out just why I was interested. When I told him I wanted to take pictures of the motors, he opened up and with some pride gave information that adds another interesting section to our series of references to good motors respected for long and satisfactory service records.

The photographs of these motors are shown here. On No. 1 the nameplate, which by the way is spread over the top in plain view and serves as something more than a decoration, read as follows: "Crocker-Wheeler, 5-hp., type 7½ c.c., No. 391, speed 600, volts 225, amps. 19.5." It's one of the old-time d.c. bipolars with ring-wound armature. Mr. Loughman told me that this motor was installed twenty-three years ago and has never been repaired so far as he knows. Furthermore, nothing else has ever been done to it except to replace the brushes and the last set was put on six years ago. This motor is now connected to a flat-bed press and operates 16 hours a day.

The nameplate on the motor shown in the other photograph read: "Robbins and Meyers, ¼-hp., patented shunt wound, speed 450, volts 230, amps. 1.3." Mr. Loughman said this motor was installed in 1901 and has a service record of no repairs beyond replacement of brushes. It is connected to a monotype caster and also operates 16 hours a day.

Here are two motors that the makers built better than they knew, with the same windings and the same commutators that have operated on a 220-volt, d.c. circuit for twenty-three years. And just now largely because we know more about insulation, dielectric strength of materials, hot-spot temperatures and the like, we hear a lot about what a motor will do or what it won't do when these technical points are on the floor for discussion. But all of the time these old fellows built by main strength and good judgment are breaking all the laws of theory and the prejudices of contenders for this or that technical point in construction.

After all, the man who buys motors to use should expect a good and inexpensive service record, but in every case he has a responsibility further than paying the cost price. He must know what he expects a motor to do and remember always that a race horse hitched to a plow is a tragedy while a mule on a race track is a comedy, but to put each in its place of greatest usefulness, simply calls for a little judgment and a lot of horse-sense. Motors are now available that are just as good as the old timers ever were and perhaps a little better, but men in plants are often penny-wise and pound-foolish when they open their pocketbooks to buy them and they really buy a theoretical horsepower instead of service. Most people want good service with good food; that's the reason they give the waiter ten per cent or more of the actual price of the food they consume. But when it comes to consuming motors, we operating men seem hungry for poor quality and low price and then kick about the bad case of indigestion that goes with it.

Practical Pete

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A Glimpse Into the Works of

The International Harvester Company

And the divisions of its manufacturing activity engaged in the production of an extensive line of agricultural implements and farm machinery, the second of a series devoted to basic American industries.

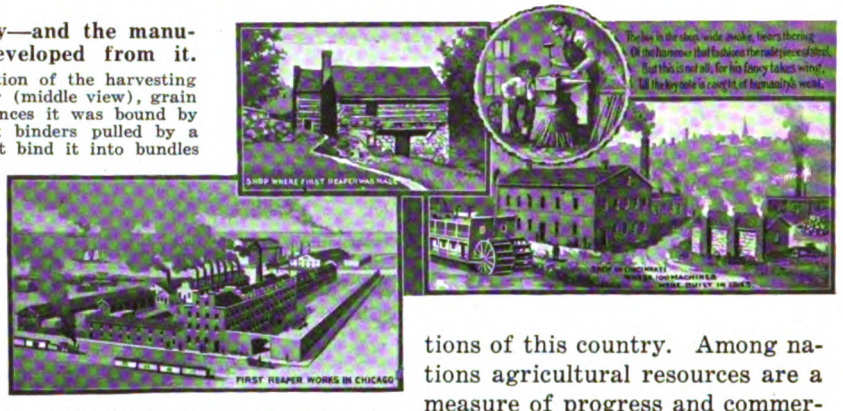




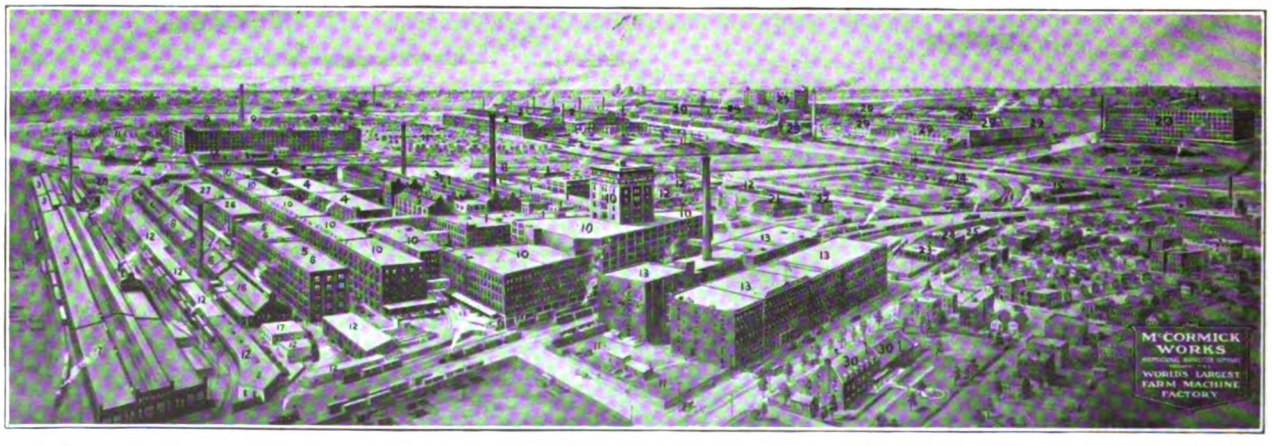


The idea—reaping grain by machinery—and the manufacturing organization which has developed from it.

Above are shown the three steps in the evolution of the harvesting of grain. When McCormick invented his reaper (middle view), grain was "cradled" by hand (left). In both instances it was bound by hand. At the right, two modern McCormick binders pulled by a tractor not only cut 25 to 35 acres a day but bind it into bundles and build six or eight bundles into a "shock," shown in the foreground which protects the grain. The pictures show the progress from 2 acres to 25 acres a day in harvesting methods. The first reaper was built in the blacksmith shop at the right in 1831. The first, but 100 machines were built in Cindevelopment of the industry was slow at cincinnati in 1845. The beginning of the present McCormick factory was laid in Chicago in 1847. When this was destroyed by fire in 1871, McCormick rebuilt on the South Branch of the Chicago River where the present plant shown by the bird's-eye view below stands. This plant is devoted to the manufacture of McCormick reaping and harvesting machinery, with the Tractor Works in the distance. The different divisions of this plant are as follows: (1) Works and engineering offices, assembling and finishing rooms; (2) Malleable iron foundry; (3) Grey iron foundry; (4) Paint and packing building; (5) Knife and grinding shop; (6) Bolt and nut shop; (7) Wheel shop; (8) Forge shop; (9) Wood shop; (10) Finished product warehouses; (11) Raw material yards; (12) Raw material sheds; (13) Twine mill; (14) Freight house; (15) Locomotive house; (16) Tempering shop; (17) Spring shop; (18) Paint grinding shop; (19) Chemical laboratory; (20) No. 5 warehouse transfer agency; (21) Hospital; (22) Fire and watch service station; (23) Garage; (24) Barn; (25) Motor truck shed; (26) and (27) Replacement parts shipment and storage; (28) Oil pumphouse; (29) Tractor works; (30) Clubhouse.



THE TRAIN of thinking between the development of an idea and the physical steps in production necessary to make it available to a wide field of usefulness is illustrated in a vivid way by the accomplishments of the International Harvester Company during the past 91 years. Every advance in the service of this all-American activity is evident to anyone who uses his eyes in travels through the agricultural sections of this country. Among nations agricultural resources are a measure of progress and commercial standing and upon it the structures of all other industries are built. Back of these resources of the United States of America stand examples of initiative and production methods that are equalled nowhere. And still back of these methods stand the machinery and tools of the agricultural industry that multiply the efforts of relatively few hands to proportions far beyond the dreams of those who saw the vision of the



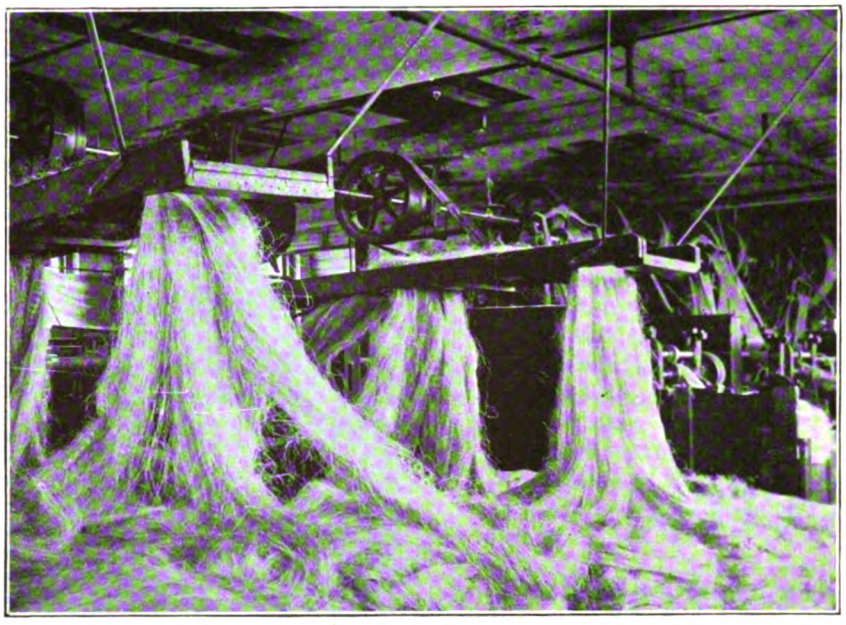
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possibilities that now are obvious.

Before Cyrus H. McCormick invented his reaper in 1831, most of the efforts of the farmer were required to supply food for his family. The surplus to feed those engaged in industry was relatively small. With practically no grain left over to trade, the farmer could buy but little.

Although this first reaper, operated by a man and a boy, cut 12 acres of grain a day in contrast to 2 acres a day by a man with a "cradle" (the grain had to be bound by hand in both cases) it was ten years before the first machine was sold, because of the prejudice against labor-saving machinery. Improvements in this reaper and new developments in other lines of agricultural machinery were rapid and in all of this activity the International Harvester Company has led with ideas and production expenditures to make them possible and permanent. Among the products now made by the Harvester Company, for instance, "P. and O." plows, date from 1842; Weber wagons, from 1845; Hoosier grain drills, from 1856; the Deering twine binder, which cuts the grain and binds it with twine, from 1879.

As a result of the perfection of machinery, the labor involved in raising a bushel of wheat has been reduced from 3 hr. and 40 min. to less than 10 minutes, a reduction of 95 per cent. Today 10 per cent of our population supplies food for the 90 per cent that are engaged in other industries and associated commercial activities.

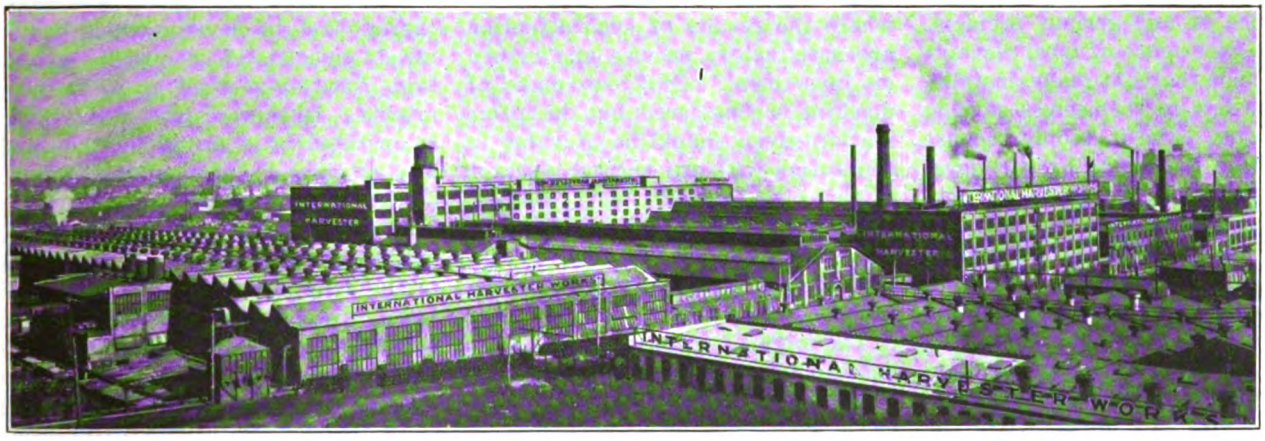


Sisal fiber going through the combing or preparing machines—one step in making binder twine, a product created by harvesting machinery.

The work of the International Harvester Company in developing better agricultural machinery and better farming methods has reflected the scope of the service this equipment provides. The wide range of implements made for the most part of iron and steel call for a skill and production facilities that embrace all the mechanical arts. In the accompanying illustrations the diversity and scope of work done from a manufacturing standpoint and the facilities required are shown at a glance. From these works and others in this country and in Europe, the farmer can secure harvesting, haying and corn machines, tractors, gas engines, motor trucks, wagons, plows, cultivators and other tillage tools.

The factories of the International Harvester Company in the United States are widely scattered over the country, each specializing in a narrow field and making only a few types of implements. Several factories are in Canada. Chicago alone has the Deering and McCormick harvester plants and twine mills, the Weber wagon works, the Tractor works, and the West Pullman works.

Tractors, gas engines and cream separators are made at the Milwaukee, Wis., works, one of the plants supplying the agricultural implement demands of the United States.



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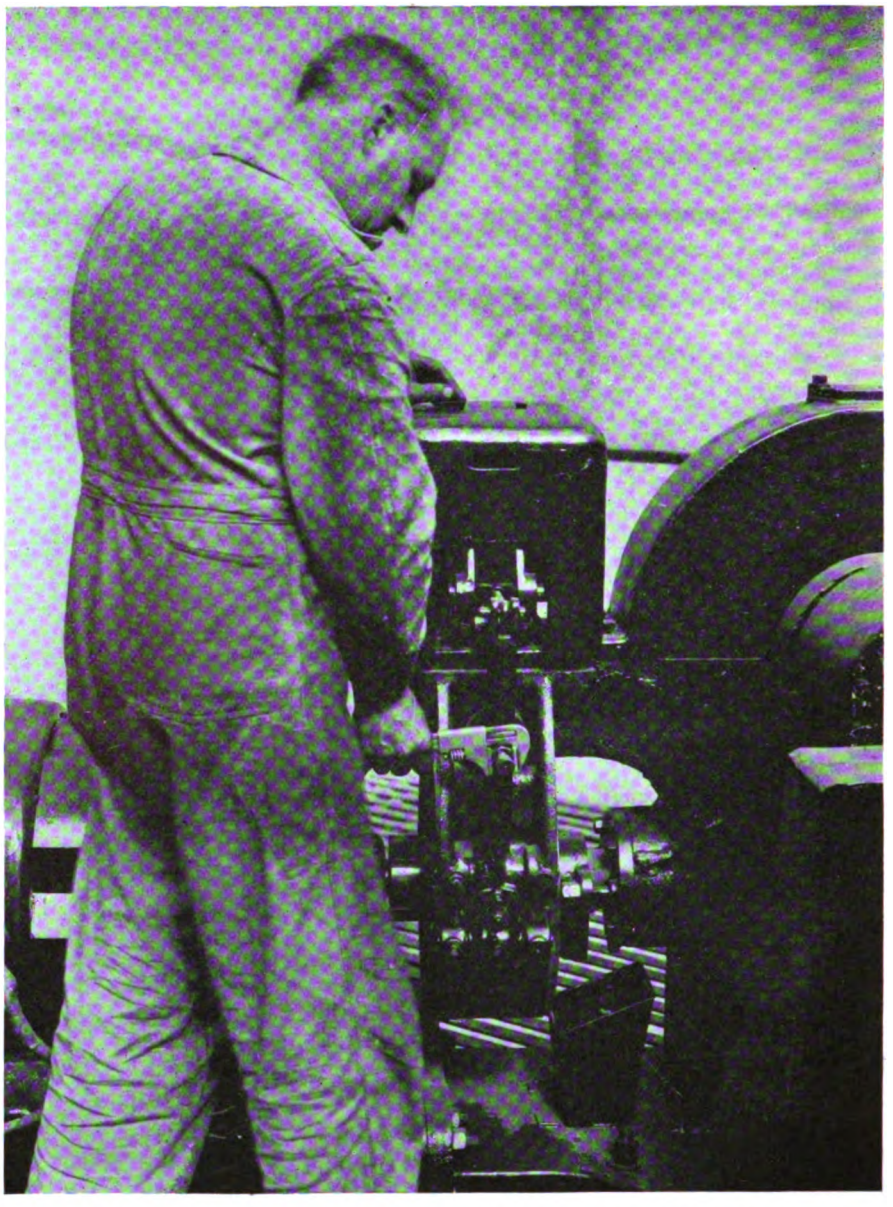
SERIOUS MISHAPS to passenger or freight elevators may result in loss of life or heavy damage to property, and even a minor failure may cause expensive interruptions of service. Proper inspection will detect trouble before it becomes serious. In this article Mr. Walsh outlines an inspection schedule for electrically driven elevators of the type used in industrial plants, and tells how to make the adjustments that are necessary.

Details of Routine for

Electric Elevator Inspection

That Will Help to Protect Both Life and Property and Insure Continuity of Service

By J. M. WALSH,
Electrical Engineer, Gurney Elevator Company, New York



The inspector is shown here adjusting the brake on a freight elevator

NINE-TENTHS of all elevator trouble results from lack of proper inspection and maintenance. Regular care and attention will go a long way toward averting minor mishaps, and will prevent the occurrence of any serious accident. It is the experience of most elevator service men that too many installations are left to themselves so long as they run. And it is only because every effort is exerted by the elevator manufacturer to make his machine as rugged and fool-proof as possible that this period of neglect can be quite prolonged before trouble develops. Given a machine and equipment of this character, why shouldn't proper inspection and upkeep pay good dividends in uninterrupted service and longer life of the installation? There is no reason why they won't, and the trouble and cost of such work is small in proportion to the benefits derived.

The inspection outline and maintenance hints herein described apply to the freight and passenger elevators in a modern industrial plant where the results of such attention are satisfactory service and return on investment. Only one make of machine is considered, but the information given should be of value in connection with any electric elevator of this class, for the same essential parts are to be found on all elevators, although the details of construction may vary somewhat in the different makes.

The regular inspection follows a definite schedule based on the order in which the different parts of the elevator installation are encountered. The schedule used divides the entire installation into five main parts, as follows: (1) The motor; (2) the machine; (3) the controller; (4) the sling and car, and (5) the hatchway or shaft appliances.

The first part of this article will describe the inspection of a direct-current freight elevator which has a rated capacity of 20,000 lb. gross load lifted at a speed of 25 ft. per minute. It serves three floors and is operated by a switch in the car. The machine is of the type known as V-groove or single-wrap traction; that is, the hoist ropes pass over the driving sheave only once, going then to the counterweight. The tractive force is applied to the hoist ropes through the V-shaped grooving on the traction sheave. The drive, from the motor, is through a single worm and gear enclosed in a cast-iron case. From the worm gear the drive is transmitted to the traction sheave

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through a cast-steel pinion and cast-iron spur gear, both with cut teeth. The pinion is located on the shaft of the worm gear, while the spur gear is mounted on the same center casting as the traction sheave. The motor is plain shunt-wound, with interpoles. It is rated at 230 volts, 100 amp., for one hour at 50 deg. C. rise, and runs at 750 r.p.m.

The elevator machine is located in a roomy, well-lighted compartment in the basement. The car and counterweight, on account of the very heavy loads carried, are roped 2:1. That is, the hoisting ropes are not fastened directly to the car and counterweight, but pass around sheaves placed on top of both and then go to fixed anchorages on beams at the top of the shaft. This reduces the load lifted by the elevator machine to one-half what it would be with direct roping. The ropes travel twice as fast as the car and its load.

The entire installation, except as noted, is inspected weekly during operation, and necessary repairs are made on Saturday afternoons, or after quitting time on other days. This weekly, general inspection is sufficient because the service is not very severe in this particular case. Once a month the elevator machine is carefully examined for signs of wear and for necessary adjustments.

Essential Divisions of an Elevator Inspection Schedule

[1] THE ELEVATOR MOTOR
Its lubrication; condition of bearings; brushes and commutator; evidences of winding troubles.

[2] THE ELEVATOR WINDING MACHINE
Its brakes, their operation and adjustment; worm gears and shaft bearings, their lubrication; bearing wear and adjustments; wear of rope grooves.

[3] THE CONTROLLER
Inspection of contactors and their adjustment; observation of condition and operation of carbon and copper contacts; bearings of contactor arms; examination of contactor coils and fusing of these circuits; thorough cleaning of controller.

[4] THE SLING AND THE CAR
Examination of the safety; its lubrication and testing.

[5] THE HATCHWAY AND SHAFT APPLIANCES
Condition of sheave which deflects ropes from traction sheave to counterweight; observation of condition of guide rails; cleaning of rails and inspection of guide shoes; condition of hatchway limit switch; condition of speed governor.

The Motor Is the First Part to Receive Attention

Starting with the motor, the inspector examines the oil well in the motor-bearing housing to see that it is kept filled to the proper level. He is careful not to overflow it, or allow the oil to get on the commutator. The well should not be filled while the motor is running; if oil overflows then, it is quite sure to get on the commutator. The oil ring is inspected to see that it is revolving freely. The oil is renewed every three months, all of the old oil being drained out and the well thoroughly flushed with lighter oil before refilling. A good grade of medium-weight machine oil is used and much care is taken to see that no dirt gets into the well, as a little dirt in the oil may cause serious bearing trouble. The inspector then tries the air gap with a feeler, preferably when the machine is not running. Under ordinary conditions bearing wear is not appreciable for a long time because of the relatively large air gap on this type of motor.

It may seem superfluous to say, "Don't oil the commutator," but the experience of most armature-repair men indicates the advisability of repeating this injunction. Oil, grease or lubricant of any sort is unnecessary on the commutator of most elevator motors, and its use will cause more trouble than it remedies. The motor on this elevator has flush mica and the brushes keep it worn down even with the copper, unless a hard spot shows up in the mica. This trouble is evidenced by a clicking noise as the high mica passes the brushes. A light application of an Ideal commutator dresser, fine grade, will remedy the trouble.

The inspector then examines the brushes for evidences of "copper picking," which ought not to happen, but occasionally does, and tests them for fit and pressure. Care is taken to see that the pressure finger bears evenly on the brush. About 1½ lb. pressure per brush is maintained on these brushes, which are ½ in. thick and 1½ in. wide. The brushes are not copper-plated, but pigtails carry the current to the brush arm. Copper-plated brushes, previously used, gave trouble when they wore down to the plating, causing arcing and burning at the commutator. The inspector cleans off any dirt that may have collected along the commutator edges of the brushes. He tightens the nuts holding the pigtail terminals to the brush arm, and also the screws holding the brush arms to the brush rocker.

A word of advice to over-ambitious inspectors: "Don't shift the brush rocker," if the motor is an interpole or commutating-pole type. The brushes were set in the proper position at the factory or on the job by the installers. To shift the brush rocker may cause faulty operation of the elevator and possibly a runaway. See that the set screw holding the brush rocker is kept tight. If the car speed seems to be uneven, look at the position of the mark on the brush rocker rim with reference to a similar mark on the end bracket. If the rocker happens to shift, accidentally, one way or the other, the car speed will be noticeably affected. In this event, shift the rocker back to make the two marks coincide.

When any electrical trouble develops it shows itself unmistakably. Grounds in the armature winding are the most frequent troubles. Removal of the armature is almost always necessary to effect proper repairs. About once a year the motor is "blown out" with an air hose or hand bellows, and the field coils and armature windings given a good coat of air-drying, finishing varnish.

Adjusting the Brake

After the motor, the brake is the next part of the elevator winding machine to be inspected. On most elevators the brake is of the spring-actuated type—that is, the pressure is applied to the brake pulley by the expanding force of a compressed spring, and is released by the pull of an electro-magnet against the spring pressure. The proper adjustment of the brake is a matter that is much neglected where regular inspections are not insisted upon, but it is a detail which, if attended to, will greatly improve the elevator service by rendering it easier to make good stops with the car. The brake on this machine is capable of three adjustments, namely: (1) Pressure on brake pulley; (2) stroke of magnet plunger, and (3) position of brake shoe relative to brake pulley. All of these adjustments are closely related and all affect the proper and efficient operation of the brake. The first adjustment is usually made by manipulation of a cap screw in the

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brake lever, which screw bears against the spring. Such a screw is shown at *A* in Fig. 2. Turning this screw in against the spring will make the stops quicker on a given load, or will enable the brake to stop heavier loads. Turning it out lessens the pressure applied to the brake pulley, which means sliding with heavy loads. This adjustment should be made with the elevator car containing about the average load. The screw is turned in or out, as the case may be, until the stop is satisfactory; then the cap screw is secured in place by its lock nut. It is necessary to have the pressure the same on each brake shoe. This point may be checked by measuring the length of each spring from the shoulder on the machine to the spring cap on the outer end of the spring. Fig. 1 shows this procedure.

This adjustment being satisfactory, the inspector looks to see what effect it has had on the stroke of the magnet. In this machine the pull of the magnet becomes less the farther out the upper end of the brake lever is forced by the spring. It may happen that the force required of the magnet is so great that it will not draw in the plunger. In that event, the second adjustment is made by turning the magnet plunger (*P*, Fig. 2), first loosening the locking nut. The plunger is drilled for a spanner wrench, but the adjustment can be made as well with the fingers. The stroke of the plunger should not be more than 1/16 in. and not less than 1/32 in. for good operation. The length of the stroke is measured between the steel head of the plunger (*H* in Fig. 2) and the frame of the magnet. There is a leather washer between the head and the magnet frame, but this is disregarded in measuring the stroke. After this adjustment, the other plunger of the magnet is set so that both will act the same.

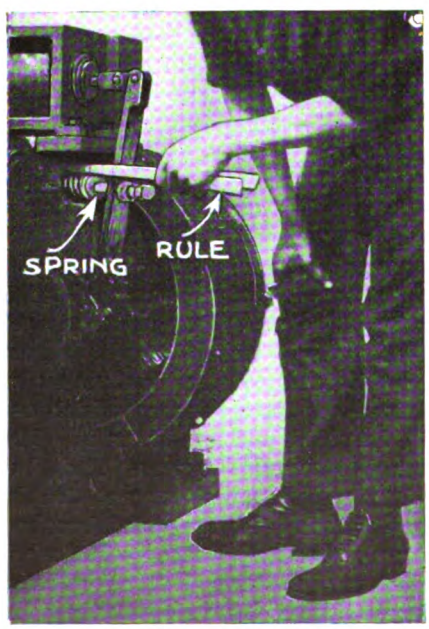
Next the inspector adjusts the position of the brake shoes. This is done with a small set screw (*D*, Fig. 2), located in the lever arm near its junction with the brake shoe. The shoe is hinged on the brake lever at *E*, and is pulled back against the brake lever by a small spring located at *F*. The set screw *D* serves as a stop for the brake shoe to rest against, and by turning the screw in or out the position of the shoe can be varied with respect to the surface of the pulley. If the screw is in too far the upper edge of the brake shoe will drag on the pulley; if it is out too far, the lower portion of the shoe will drag when the brake is applied. The weekly inspection, after the brake is once adjusted for satisfactory stops with average load, is to see that the brake shoes are not dragging. When it is found that one of them drags, prompt relief is given by manipulating the set screw *D* and locking it in position with its lock nut after getting the brake shoes clear. Two small oilers are provided in each brake shoe and its lever. These are filled weekly with medium-heavy machine oil. Sewed asbestos brake lining is used and is fastened to the cast-iron brake shoe with split copper rivets. It is necessary that the heads be countersunk well below the surface of the lining.

Condition of Worm Gear Must Be Checked

The inspector next looks after the condition of the worm shaft and its bearings. Impending trouble from these is indicated by excessive end play, and the thrust bearing should be adjusted to reduce this. The adjustment of the thrust bearing is not necessary under ordinary conditions until the machine has been in service about two or three years. For an equal length of time after each readjustment, the thrust bearing should be all right. It sometimes happens, however, that the elevator will receive extra hard running or severe duty of some sort that will cause a chuck or knock to be heard when the machine is started and stopped. If the traction sheave is closely watched, it will be seen to rock back and forth as the machine stops. These are pretty good indications that the thrust needs attention. If the inspector thinks the end play is becoming too great he makes a test of the machine when the plant is shut down. The empty elevator car is run far enough above the top landing to bottom the counterweights, and the power is shut off the controller. The two brake levers are then encircled with a piece of stout rope and drawn together so that the brake shoes are released from the pulley. The car, being overbalanced, will remain stationary. The worm shaft is then turned by hand, using a winding-bar, which is a spanner wrench made to fit the motor coupling. On some machines this can be done by applying an ordinary monkey wrench to a squared projection on the end of the motor shaft which sticks out of the bearing housing. The worm shaft is turned until it sticks and the brake pulley is marked with reference to the upper edge of one of the brake shoes. Then the worm shaft is turned in the opposite direction until it again sticks, and the movement of the mark on the brake pulley is noted carefully. In a new machine this movement will be about 1/250 of a revolution, which is around ⅛ in. on a brake pulley 10 in. in diameter. This corresponds to about 0.010 in. actual end play of this particular worm shaft, and is about the maximum that should be allowed.

When it is found that the end play is greater than this, the inspector removes the bearing cap *A*, Fig. 3, from the rear worm-shaft bearing, which is, of course, the thrust bearing. Under the edge of this cap there are several paper gaskets or washers, and he removes one or two of these. Removing too many gaskets will make the thrust bearing bind, which would be followed by excessive heating and destruction of the entire thrust. The cap is then replaced and the cap screws holding it in position tightened to their seats. He then tries the worm shaft as before for end play, and removes more gaskets if the movement has not been reduced enough. When everything is satisfactory, and the worm shaft turns easily within the prescribed limits, the brake levers are released, and the machine operated.

Fig. 1—Checking brake springs for equality of pressure.
The length of this spring must be the same as that of the spring on the opposite side of the brake (not shown here).



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The worm bearings and thrust are lubricated by the oil in the gear case, which will show a slight leakage through the gland or stuffing box of the bearing on the motor end of the worm shaft. This leakage should be caught in a small drip pan, and the inspector must see that it is emptied when full. If it is carefully strained, this oil may be returned to the gear case, but the practice is not advisable. It is just as cheap and safer to buy new oil.

In the cap which covers the thrust bearing there is a small hole closed with a pipe plug, shown in *A* of Fig. 3. If this plug is removed the inspector can determine whether the thrust bearing is getting proper lubrication from the oil in the gear case. Sometimes this bearing runs dry because the oil refuses to flow to it from the gear case. This occurs usually when the machine is first started up after an extended shut-down. When this condition is noticed, the bearing should be primed by pouring a small quantity of gear oil into it through this hole. The inspector must not forget to replace the pipe plug.

The worm gear and its shaft bearings, which include the bearing on the outboard side of the pinion, are next looked over. The condition of the worm gear can be observed through the handhole in the top of the case. Keeping the case properly filled with strained, heavy gear oil prevents excessive wear on the worm gear. The oil level should be maintained at the center of the worm shaft, as indicated by the overflow pipe in the side of the case. Fresh oil is added through the handhole from time to time. Once a year the elevator man removes all the oil, thoroughly cleans the case with light machine oil, and refills it with fresh, new gear oil. This operation, by the way, should also be performed about a month after the elevator is first installed. In too many installations the oil in the gear case is never inspected until the worm gear starts to wear out from lack of lubrication.

The Worm Gear Shaft Bearings

The worm-gear shaft bearings are of the plain, babbitted, split type. The inspector should see that the grease cups are properly filled and that the grease is fed down to the shaft. When the bearing wears down noticeably, the upper half is removed and one or two shims taken out from between the two halves of the bearing. The upper half is then fitted to the shaft with a little scraping.

Play of Worm Gear Shaft

The side play of the worm-gear shaft is closely watched on the monthly inspection. When it exceeds 1/64 in. it is time to take up the wear which has occurred on the steel washer *W*, shown in Fig. 6. There is another one of these washers on the worm-gear shaft, between the hub on the worm gear and the inside of the bearing. The washer shown is located between the outside of this bearing and the heavy cast-iron collar *C*. The collar moves along a Woodruff key on the shaft and bears against the washer *W*. The adjustment for side play is made by manipulation of the adjusting nut *N*, which fits on a thread on the shaft. The cap screws are removed and the nut tightened up until the end play is reduced to the practicable minimum. The adjustment should not make the washers bind, but should permit the worm gear to run easily. This nut and the thread upon which it moves, together with the collar *C*, form a combination which permits of adjustments for side play as fine as 1/360 in. The nut has six holes, equally spaced, and the collar ten, which gives thirty different positions in which two holes in each will line up so that the cap screws may be run through holes in the nut into the tapped holes in the collar. The thread is twelve per inch; so that each of the thirty positions will correspond to a movement of the nut and collar of 1/360 in. The wear on the washers is very slight—they need renewing about once in five years.

On the monthly overhauling the condition of the felt wipers on the inside of the gear case should be noted. These serve to prevent the oil from being splashed out of the gear case along the worm-gear shaft. They are easily renewed by removing the holding rings, which are secured with small cap screws.

The spur gearing requires the least attention on the part of the inspector. The teeth should be kept thoroughly lubricated with heavy grease and particular care taken to see that grit or dirt does not get into this grease, or on the gears. Care must be taken not to let the gear guards be bent or forced down on the gear or pinion.

The sheave-shaft, or main, bearings are of the same type as those on the worm-gear shaft. Shims are provided for wear and the bearings are kept well taken-up. On the weekly rounds the inspector examines the nuts on the bearing caps, for these will occasionally work loose. They should be kept tight.

The sheave itself is examined for excessive wear in the rope grooves. With proper loads on the ropes there should be little sheave wear after the first few months of operation. During this time it will be noticed that the ropes are wearing a seat for themselves in the V-grooving, but after this the grooves will acquire a smooth, glossy finish.

Most freight elevators are single-speed and the control equipment is quite simple. The wiring diagram, secured from the elevator manufacturer, is mounted on a thin piece of sheet iron and painted with clear shellac. It is hung on the wall near the controller, available at all times to help in tracing out trouble with the operating circuits. Intelligent study of the wiring diagram by the man in charge of the elevator installation is well repaid by the ease with which such study enables him to locate circuit trouble.

Weekly Inspection of Control Equipment

On his weekly inspection trip the elevator man observes, first of all, the operation of the various contactors. He notices whether they, particularly the armature contactors, are closing and opening in the proper sequence. From the diagram the proper order of closing is learned. If observation shows that, for example, contactor No. 2 is closing ahead of No. 1, the inspector proceeds to remedy the trouble. On some contactors a small cap screw with a locking nut on it is located under the tail-piece of the contactor arm. Loosening the locking nut permits the cap screw to be adjusted in or out, thereby varying the air gap between the arm and the core of the magnet. The gap is adjusted until the contactor closes in its proper order, whereupon the locking nut is firmly tightened. The chief cause of gap variation comes from loosening of this nut; so the inspector must look at these regularly every week.

The condition of the copper and carbon contacts next claims the attention of the inspector. The copper contacts are cleaned off carefully with sandpaper or emery cloth when-

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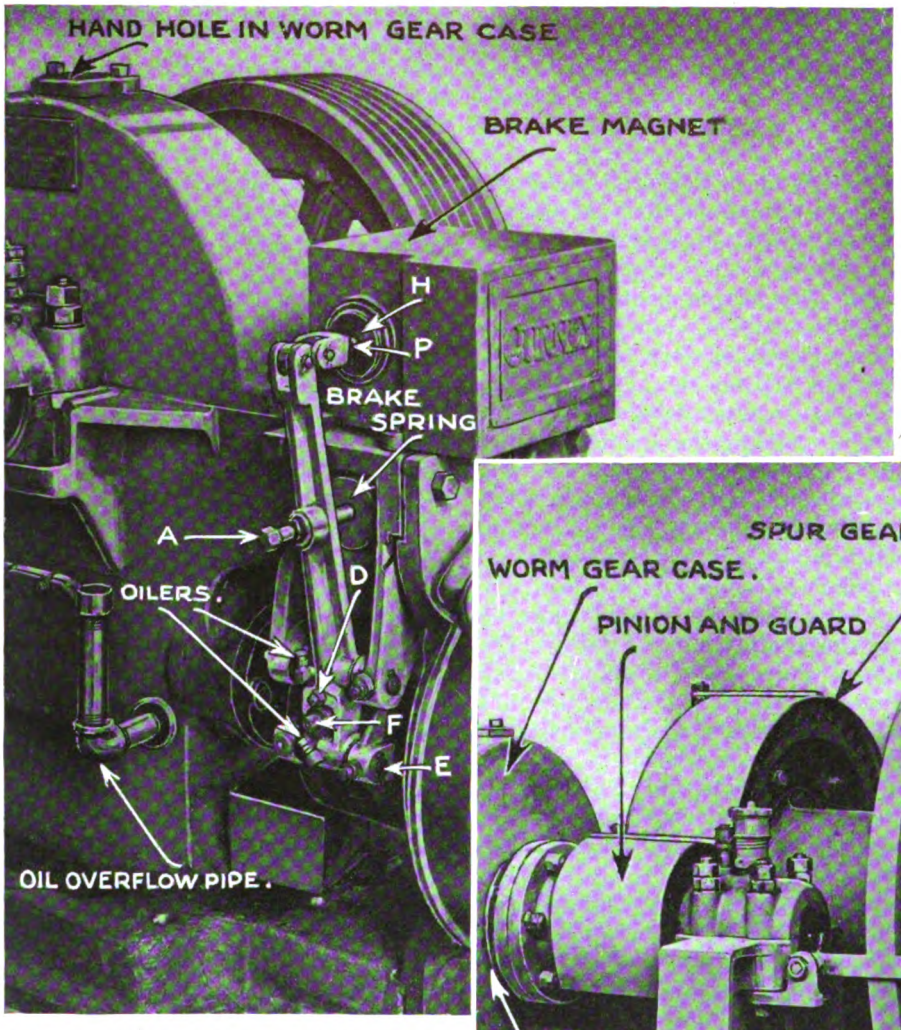
ever they show any signs of pitting or burning. The inspector is careful to remove all beading which may form on the face of the contact. When pitting or burning has worn the contact down thin, it should be renewed before the fiber bushing in the contactor arm is damaged. The gap between the carbon and the copper contact surfaces should be noted and efforts made to keep this constant by adjustment of the carbon contact in its holder. The surface of the carbon should be kept clear of the copper holder. Most controller troubles come from carelessness in allowing the carbon contacts to burn and wear away until the copper contact strikes the carbon-contact holder.

The pressure between the carbon and the copper contacts must be watched, too, because the current-carrying capacity of the contactor depends on this pressure being maintained at its original value. On the panel of the elevator under discussion a pressure of about 2½ lb. on each small contact and 5 lb. on the large contacts is about right, and the inspector checks this with a small spring balance. To do this, the main-line switch is opened and the contactor to be tested is held in its closed position by hand. A small loop of wire or string, fastened to the nut and stud on the contactor, is engaged with the hook of the balance and the reading noted when a direct pull on the balance causes the copper contact just to leave the carbon contact. When everything else is right, but the pressure is still low, the compression springs on the copper contact should be examined for temper. After long service these sometimes lose their temper—especially if the copper contacts have been allowed to wear down too thin. When it is found that the springs are weak, they are replaced with new ones, which can be obtained from the manufacturer.

The nuts on the terminal studs and contacts are examined by the inspector to see that they are tight. A loose nut on a contact will cause arcing between the terminal of the connecting cable and the contact stud, with bad results to both.

The bearings of the contactor arms are given a drop or so of machine oil on the weekly inspection trip. This serves to prevent any sticking of the contactor and insures long life to the bearing pins.

The entire controller, front and back, is carefully cleaned on the monthly overhaul; so that dirt has



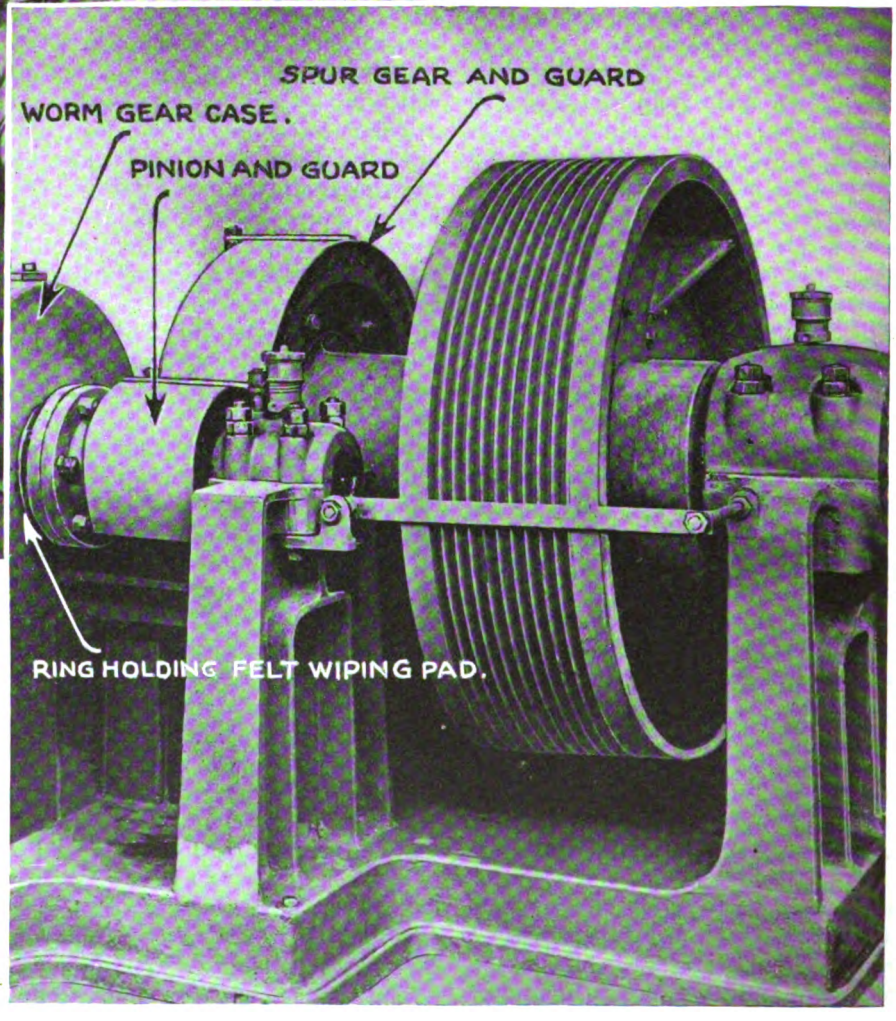


Fig. 2—Where to make adjustments on a direct-current freight elevator.

Details of inspecting and adjusting are given in the text. The machine shown is for an elevator which is rated to lift 20,000 lb. gross at 25 ft. per minute. The motor is rated 230 volts, 100 amp. for one hour at 50 deg. C. rise, 750 r.p.m.

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Fig. 4—A form which helps the elevator inspector to remember.
It also serves to keep the superintendent informed of the condition of the machines.

MONTHLY INSPECTION REPORT ON ELEVATORS

DATE_____ 192__ INSPECTION MADE BY_____

Examine all parts of elevator and if found in good condition, place a check (✓) in space allotted under each item. If not in good condition, use a cross (X) and note details under "Remarks"

ELEVATOR NO.	ENGINE	BRAKE	GEARS	CONTROLLER	BELTS	CAR	GUIDES	CAR SHOES	COUNT SHOES	COUNTER SHOES	SHAFT	BEARINGS	PIT	GATES	DOORS	SWITCHES	LIGHTS	SAFETY DEVICES	HOLES	CABLES	WIRING			REMARKS
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no chance to collect and cause short-circuits or grounds. Care is taken to see that no metallic objects are placed on top of the resistance grids. On the monthly cleaning, all nuts on the back of the board are examined to insure their being tight.

Contactor coils give little trouble from burn-outs, but when one does fail it is easily and quickly replaced with the "spare" always kept on hand. In case the burn-out occurs on one of the armature contactors and no spare is available, the damaged coil may be bridged and operation continued. This is only a temporary expedient, however, as the other contactor coils will heat much more than under ordinary conditions. Bridging should be resorted to only in case of urgent necessity. Burn-out of the coil on the dynamic-brake contactor need not interfere seriously with the operation of the machine beyond rendering the stops harder to make, due to the absence of full dynamic braking. It is not necessary to bridge this contactor coil in case of burn-out, but it should be replaced as soon as possible, in order to have satisfactory car stops. A burn-out of the field contactor will cause the car to run at low speed and the field coils of the motor to heat up abnormally, if the operation of the car continues. For emergency work this is tolerated, of course, but the defective coil is always replaced as soon as possible. Main-line contactor coils must always be replaced before operation is attempted.

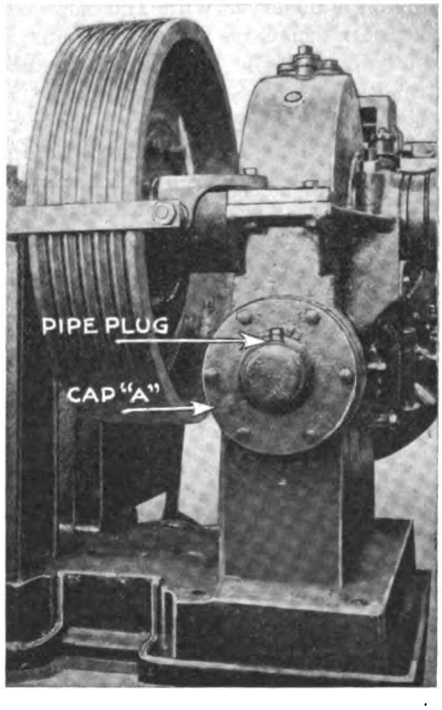
In replacing the baby fuses on coils care is taken to use fuses of no higher rating than those originally furnished with the controller. Contactor-coil troubles are mostly due to fusing these circuits too high.

Keeping the Sling and the Car in Condition

Leaving the machine room, the inspector goes to the elevator car. He is concerned here with the car switch which controls the operation of the machine. If it is working well and everything appears to be in good condition, it is passed on the weekly inspection trip. Once a month the cover is removed and the condition of the contacts observed. If pitted or burned, they are sanded smooth and cleaned. A little oil is placed on the bearing of the switch arm, and any dirt that may have collected in the case is removed.

The inspection of the sling means chiefly the examination of the "safety." This is located underneath the car platform, and is best inspected from the pit, see Fig. 5. Once a month is often enough to look it over. The car is lowered so that the inspector can easily examine all working parts of the device while standing in the pit or on a plank over the hatchway at the first floor. This safety is of the clamp type, wherein two steel jaws clamp the rails. These jaws are actuated by wedge-shaped nuts within which turns a threaded shaft revolved by the unrolling of the tail-rope from a drum fastened on it. The various moving parts are greased and their condition observed. The guide shoes on the car are also examined at this time. The shoes on the bottom of the car require special attention because the side play of the car, due to wear on the sides of this set of shoes, must not become sufficient to permit the jaws of the safety to come in contact with the guide rails. This condition would result in wear taking place on the surface of these jaws, or in the jaws cutting the rails. The shoes are of cast iron, fitted with renewable cast-iron gibs. These gibs are renewed as soon as they become so worn that there is a possibility of the safety jaws touching the rails.

Attached to the safety plank is a simple switch enclosed in a metal box (shown in Fig. 5) which serves to stop the elevator machine when the safety is applied. It is actuated mechanically by the safety. When



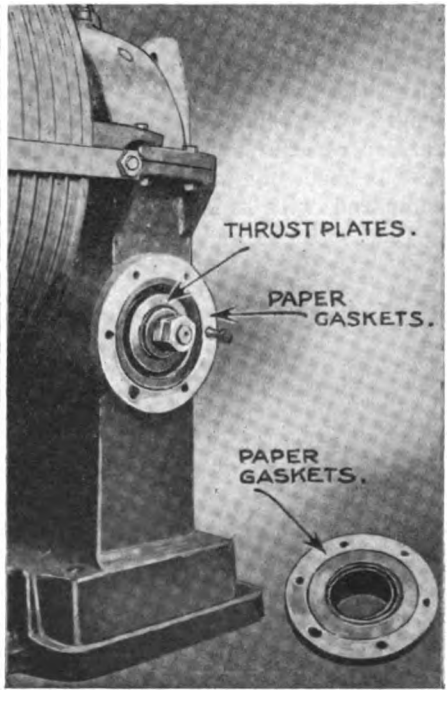


Fig. 3—End play of worm shaft is adjusted by means of paper gaskets.
This is the thrust bearing of the worm shaft. Cap *A* is removed and then the paper gaskets are put in or taken out. The worm should have about 0.010 in. end play.

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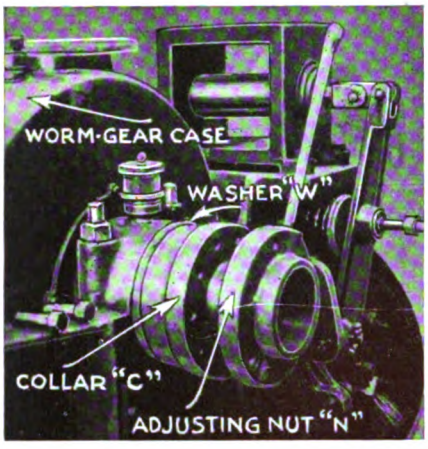


Fig. 6—Adjustment is made here for side play of worm gear.

The nut *N* bears against the collar *C*, which slides on the shaft but is keyed to it. The collar presses against a washer, *W*, which rests on the bearing. The two cap screws are employed to lock the nut to the collar. In Fig. 8 this nut is shown in place.

the latter is inspected the cover is removed from this box and the operation of the switch tested. Beyond keeping it clean and the bearing parts oiled, it requires no attention.

The safety is tested about once every six months—oftener if it is called into use very frequently. One of the handiest ways of making this test is to get on top of car and lift the governor clutch from the releasing carrier by means of a spring finger which permits it to slip out when the governor rope is pulled upward. The amount of tail rope run off is an indication of the condition of the jaws, rolls and wedges of the safety. It should be known how much tail rope was run off when the safety was first tested. If this information is not available, the test should be made as soon as possible after the job is installed and the length of rope above the releasing carrier carefully noted. When the test is made again the results are compared with this figure. When the two readings differ greatly, the chances are that the jaws are worn enough to warrant the installation of new ones.

It may be well to say a word about rewinding the tail rope on the safety drum after the above test, or, for that matter, after any occasion when the safety has been applied. To do this properly requires two men, one in the car to manipulate the wrench which rotates the safety drum and one under the car to guide the rope properly into the grooving on the drum. After releasing the safety by means of the wrench, the car should be run to the lower floor, where a man in the pit or standing on a plank across the hatchway at the first floor can reach the safety drum. Then, as the man in the car rotates the safety drum, the second man carefully guides the tail rope into the grooving on the drum. Unless this is done the rope is very likely to wind unevenly and pile up so that the next time the safety is called upon to act there is danger of the rope binding and possibly breaking before the safety jaw can grip.

Hatchway Appliances Are the Most Likely to Be Neglected

The inspector comes now to the hatchway, and it is here that the parts of the installation are most likely to be neglected. This is because of the comparative inaccessibility of these parts and also because of a lack of knowledge as to what and where they are. The cables are included in this part of the inspection schedule. Their general condition is observed while the inspector is in the machine room, and this is sufficient if the elevator insurance inspections are regularly made. It is found that by following the recommendations of the insurance inspector as to rope renewal, satisfactory cable service is obtained.

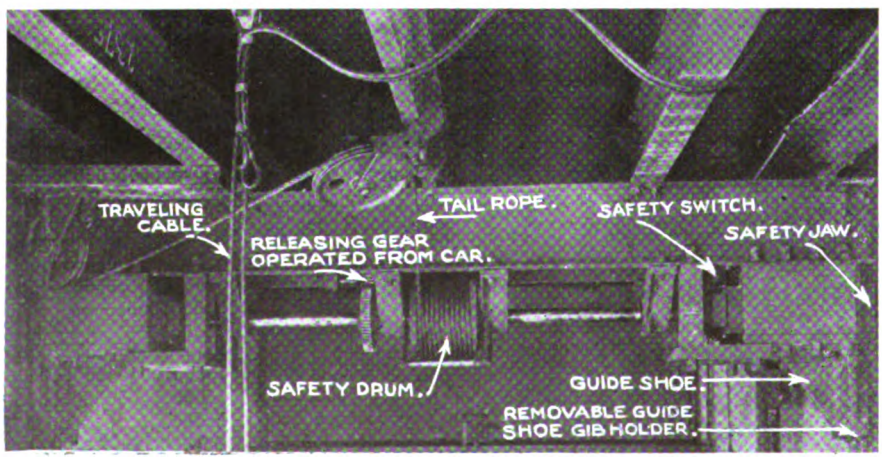


Fig. 5—The "safety" should be inspected monthly.

This picture shows the bottom of the elevator car with the various parts of the safety equipment.

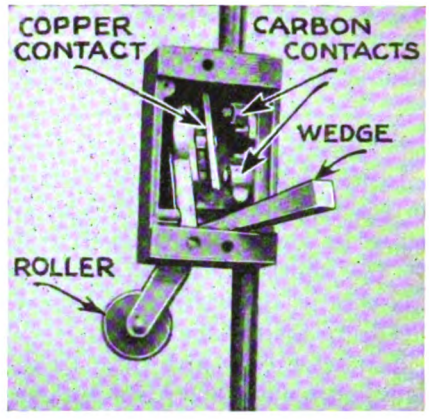


Fig. 7—How contacts of hatchway limit switch are examined.

A wedge is used to hold the contacts open while they are being inspected and adjusted.

The sheave which deflects the ropes leading from the traction sheave to the counterweight is fastened to the ceiling beams of the machine room. The grease cups on this sheave are kept filled and a turn or two given the cups on the weekly inspection. Wear on the moving parts of this sheave is found to be slight if the lubrication is properly attended to.

The inspector now gets on top of the car and sees to the condition of the sheave located there. The grease cups on this sheave are carefully looked after because the heavy loads on the shaft of the sheave will cause rapid wear if the lubrication is neglected. They are carefully cleaned all over once a month.

The car is now operated by an assistant, the inspector remaining on top to observe the condition of the rails as the car proceeds up the hatchway. Dirty, gritty guide rails mean increased friction with resultant increased power consumption. Where there is much dust in the air, or where the hatchway is used as a convenient dirt chute, the greasy rails will collect enough dirt to make an appreciable difference in the power bill. When such conditions are found, the man in charge of the machine cleans the rails with kerosene and rags—waste has a tendency to stick to the rails. After cleaning, the rails are re-oiled. Local conditions govern the frequency with which cleaning is needed, but a careful inspector will know when it should be done. The counterweight guide

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rails do not require such careful attention, as there is more play between them and the slots in the weights, and little or no side strain.

The guide shoes on top of the car are examined at this time. Like the lower guide shoes, they have renewable gibs, which in this set are renewed when the play between the rail and the gib of the shoe is more than 1/32 in.

The car is stopped in its upward journey when the sheave on the counterweight comes opposite the inspector. The same careful attention is given to this sheave as to the one on top of the car.

As the car nears the upper limit of travel the inspector prepares to note the condition of the hatchway limit switch which is fastened to one side of the shaft. This switch stops the car if the operator runs beyond the final landing. Fig. 7 shows this switch with the cover removed. A similar switch is located near the bottom of the shaft. These switches are actuated by an angle-iron cam attached to the side of the car, and the inspector satisfies himself that this cam is firmly in place. On the monthly inspection the cover is removed from the hatchway limit switch and the contacts cleaned and adjusted the same as the copper and carbon contacts on the controller. A drop or two of oil is applied to the moving parts.

The inspector gets off the top of the car at the upper landing and goes to the pent house. Here are located the overhead sheaves and the speed governor. There are two overhead sheaves on this installation. They are lubricated with grease cups which are kept properly filled, and the grease fed down to the bearing. Any dirt collecting around them is carefully cleaned away.

The speed governor, if of a simple type, requires attention only to the grease cup located in its fixed shaft. When this is kept filled and properly adjusted the governor gives no trouble, if dirt and grit are kept away from it. The condition of the governor cable is observed at this time. Unless the safety is applied through the action of the governor, the wear on the rope is very little.

For an alternating-current elevator or a passenger elevator, the care is about the same as that already described for a direct-current freight elevator. With the alternating-current system the maintenance is slightly different with regard to the motor, brakes and controller. A passenger elevator differs from a freight elevator chiefly in the construction of the sling and of the winding machine.

Care of Alternating-Current Passenger Elevator

The elevator which will be particularly described is located in a factory and serves four floors. It is rated to lift 2,500 lb. gross load at a car speed of 100 ft. per minute and is driven by a squirrel-cage induction motor. The motor is rated at 230 volts, 10 hp. for 30 minutes at 50 deg. C. rise. It is wound for two-phase, 60 cycles, and runs at a full-load speed of 960 r.p.m. (synchronous speed, 1200 r.p.m.).

Unlike the freight elevator previously described, this machine is located in a pent house directly over the top of the hatchway or shaft and is roped directly to the car instead of employing the 2:1 roping arrangement, as on the freight machine. It is, however, of the same type as the freight elevator, namely, V-groove or single-wrap traction, but the drive is made from the motor directly through the worm and worm gear to the traction sheave without any spur gearing coming in between as in the case of the other. The driving or traction sheave is on the same shaft as the worm gear, both being bolted to the same cast-iron center.

The operation of the elevator is controlled by a car switch the same as the freight elevator. The whole equipment, excepting the car safety and the hatchway appliances, is inspected weekly and once a month everything gets a thorough looking over for necessary adjustments and cleaning. The same schedule is followed as was outlined for the freight elevator, and the adjustments and tests described apply to this machine except as noted under the corresponding headings below.

Care of Alternating-Current Elevator Motor

Starting at the motor, the inspector, knowing that the troubles most likely to occur are the result of worn bearings, looks first to see that the lubrication of the two motor bearings is being properly accomplished. The oil well is kept filled to the proper level and care taken to see that the oil ring is revolving freely. There is the greatest need for keeping the oil free from grit or dirt. A hot bearing, with possible stalling of the motor, is one result of grit in the oil. Once every three months the oil well is drained out, cleaned with new, light oil and refilled with clean, fresh oil of medium consistency.

Next the inspector tries the air gap, using the gage supplied with the motor. When the gage refuses to enter freely between the rotor and the stator, it is time to renew the bearings. The gap should be tested in at least four places about equally spaced around the rotor, paying particular attention to the gap at the lower half. If the motor stalls while in operation it may be found that the rotor has been rubbing against the stator so much that the friction has been greater than the pull-out torque of the motor. When this happens the motor hums loudly and excessive current flows until the fuses blow.

On the monthly inspection the condition of the rotor rings should be examined. If the motor has been stalled very often there may be a tendency for the end rings to become loose or otherwise out of condition. Once a year the stator windings are thoroughly cleaned out with an air hose or a common hand bellows, after which they are given a coat of black, oil-proof, air-drying varnish.

Sometimes it happens that the motor refuses to start when the car switch is manipulated. The motor howls and the fuses blow. This state of affairs is usually the result of low line voltage. The torque or turning power of an induction motor varies directly as the square of the voltage at the motor terminals. When this voltage falls off by any appreciable amount the torque which the motor is able to exert may not be sufficient to start the elevator. The remedy for this condition is, of course, larger transformers and supply lines or better regulation of voltage by the power company. If the motor gets low voltage very frequently, there is danger of burning out the windings. When the voltage is normal and there is nothing wrong mechanically, but the motor refuses to start, an open circuit in the windings is to be looked for.

Setting Alternating-Current Brakes

The adjustment of the brake and brake shoes is the same as on the direct-current machine, with the exception of the adjustment for stroke of magnet. This is made by manipulating eye-bolt *C*, shown in Fig. 8. The locking nut is loosened, the bearing-pin *P* removed and, by means

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of the threaded eye-bolt, the armature of the magnet moved closer to the poles until it is snapped up satisfactorily when the car switch is operated. The other armature is adjusted the same as this one; so that they will act alike. When the adjustment is satisfactory the eye-bolt is locked with the locking nut and the cotter pins are properly replaced in the bearing pin *P*. If the atmosphere is inclined to be dusty or dirty, the cover of the brake magnet should be removed about every two or three weeks and the contact faces of the armature and magnet carefully cleaned, so as to insure quiet operation.

Care of Alternating-Current Control Board

What was said about contact pressure for the direct-current panel and so on holds good for this controller also, as the construction of the contactors is similar. In addition, however, there is the necessity of keeping the contact faces of the magnets and armatures clean and free from grease and dirt. This is to insure quiet operation of the contactors. The presence of dirt or grit on the surface of the magnet or armature will cause the contactor to hum when it is closed. The blow of the contactor arm at the moment of seating is eased by an air dash-pot which is attached to the back of the control panel. The dash-pot needs no attention from the inspector, beyond keeping the valve opening clear of dirt and the piston rod slightly oiled.

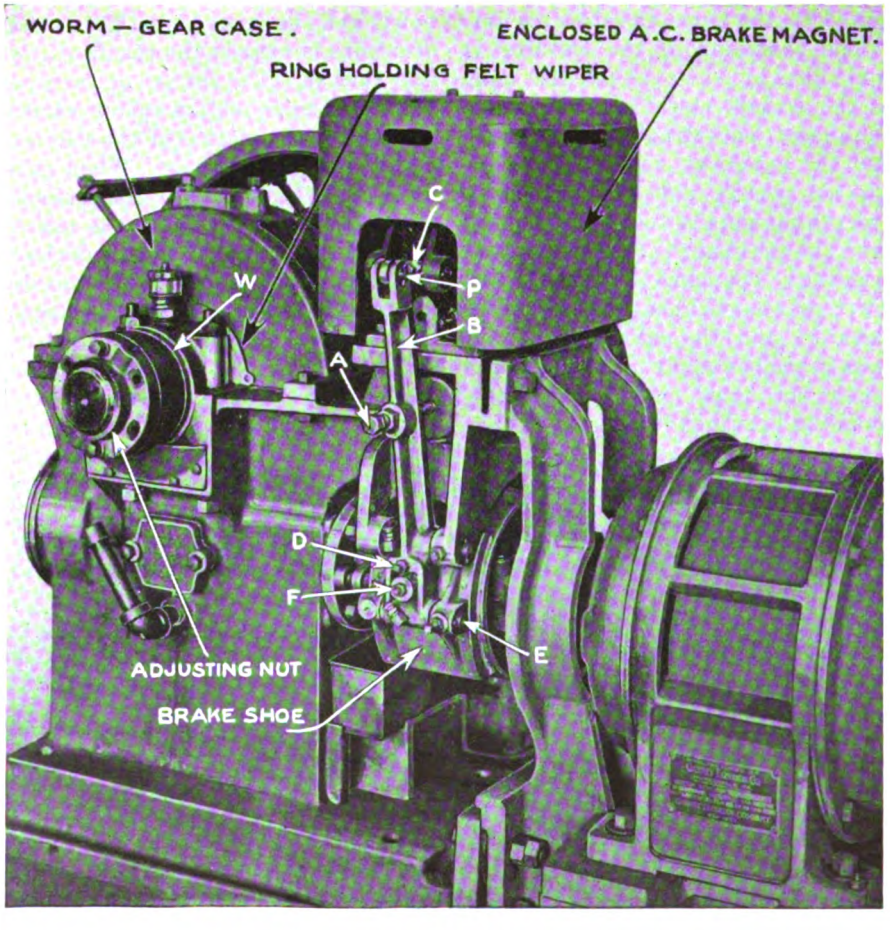
The inspector after seeing that the nuts on the contact studs are tight, looks at the phase-failure and phase-reversal relay. This is enclosed in a cast-iron box located near the top of the control panel. The purpose of this relay, as its name indicates, is to prevent the operation of the motor on less than the proper number of phases, or when the phases are reversed in their relation to each other. The inspector on his weekly trips removes the cover and examines the contacts of the relay. Because of the comparatively light pressure between the two contact surfaces in this device, they must be kept very clean and free from dirt; failure to make proper contact will render the car inoperative because the operating circuit is made through this relay.

In case of a burn-out of either of the line-contactor coils a new coil must be inserted before operation of the car can be resumed. If one or more of the phase-relay coils burns out, the two upper terminals of the relay may be tied together in order to permit operation of the car. But it must be remembered that this action removes the protective features of the relay and that, consequently, operation under these conditions must be very carefully watched.

The back of the control panel is inspected for loose nuts or wires, and the whole thoroughly cleaned once a month.

Fig. 8—This shows where adjustments are made on alternating-current elevator machine.

This machine is for a passenger elevator rated at 2,500 lb. gross load, 100 ft. per minute. The squirrel-cage motor is rated 10 hp. for 30 min. at 50 deg. C. rise, 230 volts, two phases, 60 cycles, 960 r.p.m.



Guide Shoes of Passenger Car

Inspection and tests of the safety apparatus on the car are carried out as for the freight elevator. The guide shoes, however, are a different type. They are solid cast-iron without gibs, are set in holders and are self-adjusting, for a certain amount of wear, by means of a compression spring located in the socket of the holder. When worn so that the car has too much side play they are adjusted by loosening a set screw which holds the spring stop in the socket and driving the stop forward enough to make the spring again hold the shoe up to the rail. They are renewed when they become so worn that there is more than 1/32 in. between the side of the rail and the guide shoe. There is, of course, no sheave on the top of the car, since the ropes are attached directly to the car sling.

While the many adjustments and repairs which may become necessary have been discussed in detail, it must be remembered that it is not necessary to perform each one of them every time the inspector examines the equipment. Even on the monthly overhauling it may not be necessary to dissect the thrust bearing or to test the safety. It is well to bear in mind that too much tinkering and adjusting is as bad as too little.

Cleanliness is the first requisite for maintaining safe, efficient and economical operation of the elevator. Next to this is proper lubrication. Regularly and intelligently attended to, using clean oils and greases, it lengthens greatly the life of the equipment. If these two items are given the attention they deserve the repair work and the cost of replacement will be small.

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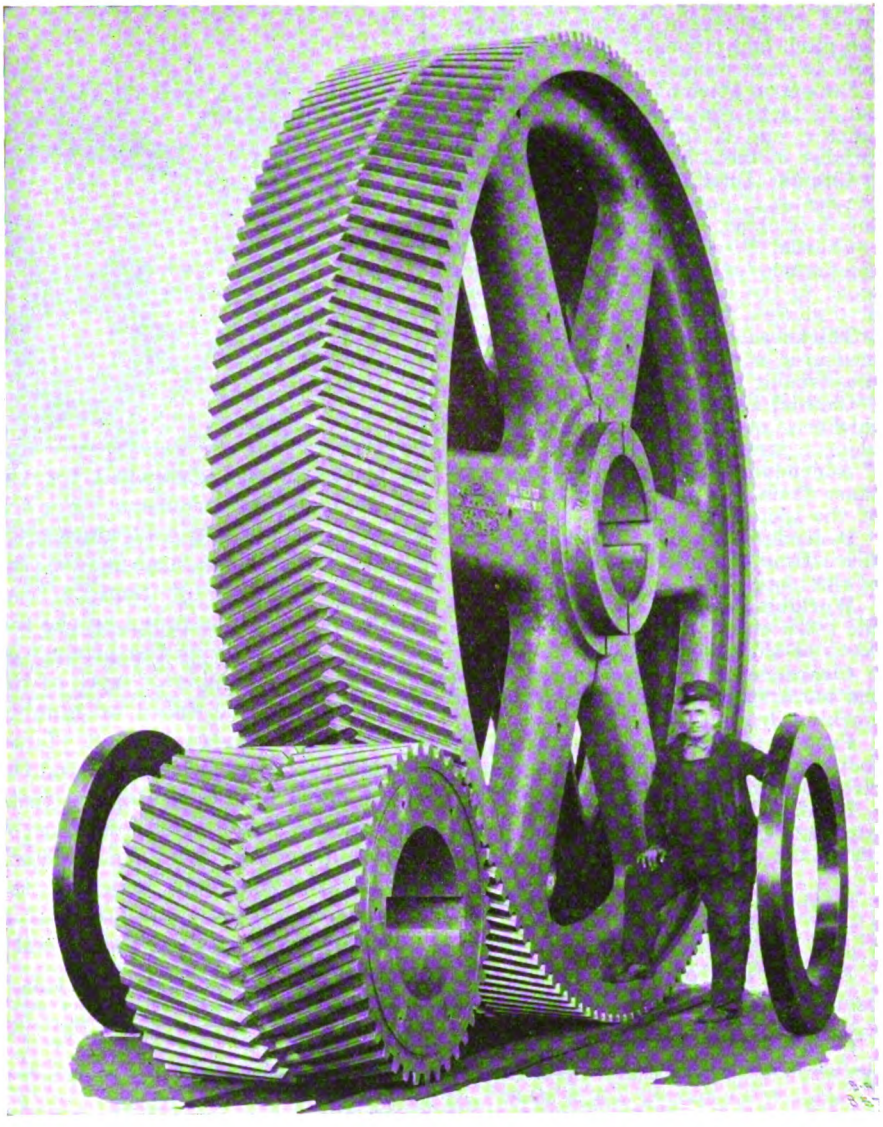
GEARING PLAYS a prominent part not only in the design of the majority of machines, but in the transmission of power from motors or other prime movers to the machines which they operate. In this and a succeeding article the salient characteristics of the various kinds of gears are discussed, and information given which should be known to everyone who has to solve gear problems and make the decisions involved in the use of such equipment.

Some Pointers on the

Use of Gears and Pinions

That Will Help the User to Select and Apply Them to the Best Advantage

By G. A. VAN BRUNT,
Managing Editor, Industrial Engineer



This is a herringbone gear and pinion for reducing speed from 110 r.p.m. to 30 r.p.m. between engine and hot rolling mill. At peak load 7,000 hp. is transmitted.

GEARS and pinions provide a simple and usually efficient means of transmitting power at a constant speed ratio and are among the most widely used of mechanical devices. Transmission of power may be between shafts on the same or different planes, and the speed of rotation of the driven shaft may, as desired, be greater, the same as, or less than that of the driving shaft. In order to meet the various conditions encountered and render the service required, several distinct types or classes of gears have been developed and are in wide use. A rough but convenient way of classifying gears is based on the service which they perform, as follows: (1) Gears connecting parallel shafts. This includes spur, helical, herringbone and internal gears. (2) Gears connecting at any angle shafts in the same plane. Bevel gears fall in this class. (3) Gears connecting at any angle shafts not in the same plane. This class embraces worm, spiral and skew bevel gears.

Spur Gears are the simplest form of toothed wheel, with the teeth parallel to the axis. The fundamental shape of the teeth and the accuracy with which they are formed determine whether the operation of the gears will be smooth, efficient and noiseless or whether the movement of the driven gear will be made up of alternate accelerations and retardations which will not only absorb a large amount of power, but tend to disintegrate the material of which the gear is constructed. Various forms of teeth have been proposed and used to some extent, but what is known as the involute form is now employed almost exclusively. Although this is a subject which is of more interest to the designer than to the user of spur gears, it may be said that an involute curve is generated by rolling a straight line on a circle; any point on this line then describes an involute. It is also described by unwinding a string from a circle.

In order to have a clear understanding of the terms used in describing and in making calculations for gears, the following definitions should be kept in mind:

Pitch Diameters and Pitch Circles—If two circular disks are in contact, so that when one disk is revolved it will drive the other disk by frictional force, the diameters of the disks are then the same as the pitch diameters of corresponding gears, and the circumference of these disks, which are tangent to or touch each other, represent the pitch circles of the gears.

Outside Diameter of a gear is the diameter measured over tops of teeth.

Root Diameter of a gear is the diameter measured at the bottom or roots of the teeth.

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Center Distance is the distance between the centers of two meshing gears, the pitch and circles of which are tangent to each other.

Diametral Pitch of a gear is the number of teeth for each inch of pitch diameter, and is found by dividing the number of teeth by the pitch diameter.

Circular Pitch is the distance from the center of one tooth to the center of the next along the pitch circle.

Chordal Pitch is the distance from the center (or the pitch circle) of one tooth to the center of the next, measured along a straight line.

Thickness of the Tooth is generally measured at the pitch circle and along the circular arc.

Chordal Thickness of the Tooth is the thickness at the pitch circle measured along a straight line or chord.

Addendum of Gear Tooth is the distance from the pitch circle to the top of the tooth.

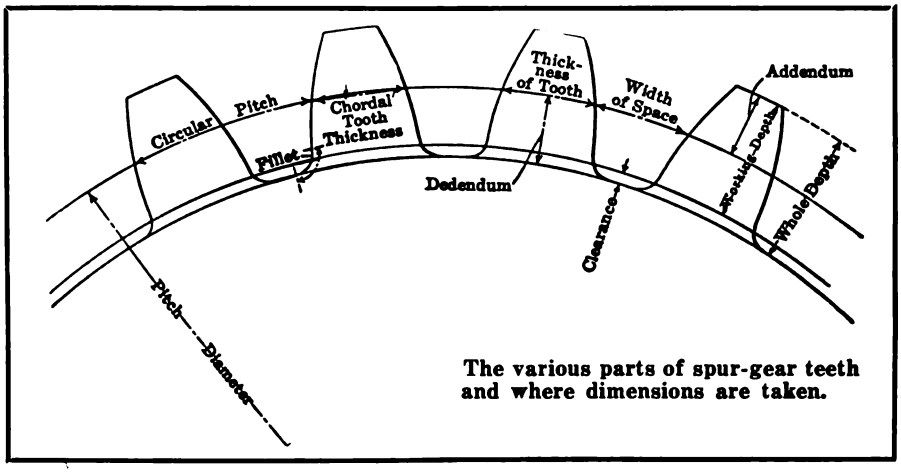
Dedendum of a Gear Tooth is the distance from the pitch circle to the root of the tooth.

Working Depth is the depth to which the teeth enter the spaces between the teeth of the meshing gear.

Clearance is the amount by which the tooth space is cut deeper than the working depth.

Face of the Tooth is that part of the tooth curve that is between the outside circumference and the pitch circle.

Flank of the Tooth is that part of the working depth of the tooth which comes inside the pitch circle.



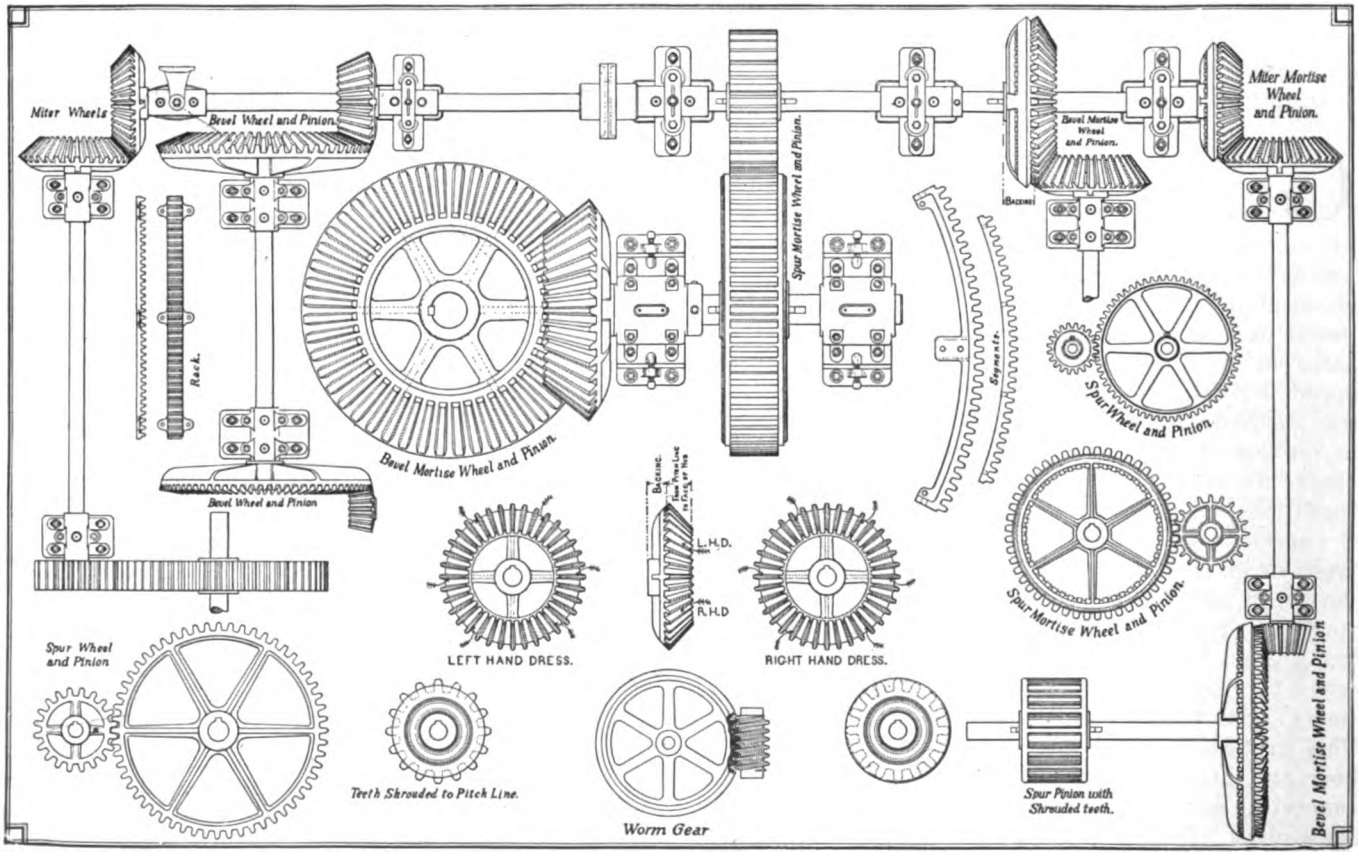
The various parts of spur-gear teeth and where dimensions are taken.

CALCULATIONS FOR SPEED AND POWER OF GEARS

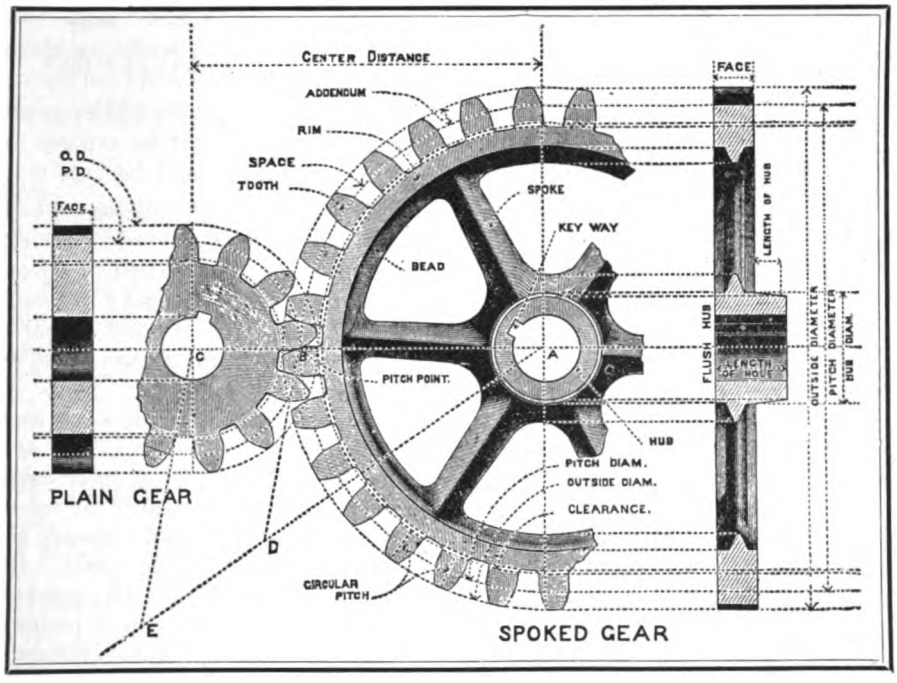
Among the problems which the user of gears must solve are those relating to the speed. Simple formulas have been developed for the solution of such problems. For example, if the speed and number of teeth of one gear are known, the speed or number of teeth of the mating gear can be found by the following rule: Divide the product of the speed and number of teeth of the first gear by the speed or number of teeth of the second gear. Thus, assume that it is required to find the r.p.m. of a pinion having 20 teeth and mated with a gear having 80 teeth and turning 300 r.p.m.. Then: $(80\times300)\div20=1200$, which is the speed of the pinion. Or, if it were desired to find the number of teeth in a pinion to be mated with the above gear so that the speed of the pinion should be 1200 r.p.m.: $(80\times300)\div1200=20$, or required number of teeth in the pinion.

The same procedure is followed when dealing with a train of gears; that is, the continued product of the pinions and the continued product of the gears is used in the same way as for a single pinion and gear. For example, assume a train of gears, A, B and C, with pinions a, b and c. Gear A has 100 teeth, B 70 teeth and C 60 teeth. Pinion a has 15 teeth, b 18 teeth and c 24 teeth. Gear A has a speed of 10 r.p.m.. What is the speed of pinion c? The teeth of

Diagrammatic view of the several kinds of gears.
This illustration shows the shape and working relation of the gears in ordinary use. It is reproduced with acknowledgments to Christiana Machine Co., Christiana, Pa.



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How the parts of a spur gear and pinion are designated.
This illustration is reproduced with acknowledgements to Philadelphia Gear Works, Philadelphia, Pa.

gears A×B×C=100×70×60=420,000. The teeth of pinions a×b×c=15×18×24=6,480. Therefore, (420,000×10)÷6,480=648, or the speed of pinion c.

It is also sometimes necessary to determine the horsepower that can be transmitted by a cast-iron spur gear. This may be calculated by the following formula, which is taken from literature issued by the Philadelphia Gear Works, Philadelphia, Pa.: For spur gears, Hp.=(F×T²×V)÷(L×53), where F=width or face of tooth, in inches; T=thickness of tooth at pitch line, in inches; V=velocity at pitch line in feet per minute; L=length of tooth from root to point, in inches. This formula allows a safety factor of 8 and is based on an ultimate tensile strength of 30,000 lb. per square inch for the cast iron.

Another rule is given by the Christiana Machine Company, Christiana, Pa., as follows: To find the power a cast-iron spur gear will

Some Information That Is Frequently Needed

To obtain the distance between the centers of two gears, add the number of teeth together and divide half the sum by the diametral pitch.

To find the pitch diameter of a pair of gears, divide the centers by one-half the sum of the teeth and multiply the quotient by the number of teeth in each gear. The product is the pitch diameter of each gear.

The circular pitch of a gear is equal to the constant 3.1416 divided by the diametral pitch.

To find the number of teeth in a gear and pinion, multiply the center distance by two times the diametral pitch and divide the product by the ratio of pinion plus ratio of gear. This quotient multiplied by ratio of pinion equals number of teeth in pinion, and by ratio of gear equals number of teeth in gear.

To find speed or number of teeth of one gear, when speed and number of teeth of mating gear are known: Divide product of speed and number of teeth of first gear by the speed or number of teeth of the second gear.

For a train of gears use the continued product of the gears and the continued product of the pinions as in the case of a single gear and pinion.

For Every-Day Calculations On Gears These Rules Will Come in Handy

No. of Rule	To Find	Having	Rule
1	Diametral Pitch	Circular Pitch	Divide 3.1416 by the Circular Pitch.
2	Diametral Pitch	Pitch Diameter and Number of Teeth	Divide Number of Teeth by Pitch Diameter.
3	Diametral Pitch	Outside Diameter and Number of Teeth	Divide Number of Teeth plus 2 by Outside Diameter.
4	Pitch Diameter	No. of Teeth and Diametral Pitch	Divide Number of Teeth by Diametral Pitch.
5	Pitch Diameter	No. of Teeth and Outside Diameter	Divide the product of Outside Diameter and No. of Teeth by No. of Teeth plus 2.
6	Pitch Diameter	Outside Diameter and Diametral Pitch	Subtract from the Outside Diameter the quotient of 2 divided by the Diametral Pitch.
7	Pitch Diameter	Addendum and Number of Teeth	Multiply Addendum by the Number of Teeth.
8	Outside Diameter	Number of Teeth and Diametral Pitch	Divide Number of Teeth plus 2 by the Diametral Pitch.
9	Outside Diameter	Pitch Diameter and Diametral Pitch	Add to the Pitch Diameter the quotient of 2 divided by the Diametral Pitch.
10	Outside Diameter	Pitch Diameter and Number of Teeth	Divide the Number of Teeth plus 2 by the quotient of Number of Teeth divided by Pitch Diameter.
11	Outside Diameter	Number of Teeth and Addendum	Multiply the Number of Teeth plus 2 by Addendum.
12	Number of Teeth	Pitch Diameter and Diametral Pitch	Multiply Pitch Diameter by the Diametral Pitch
13	Number of Teeth	Outside Diameter and Diametral Pitch	Multiply Outside Diameter by the Diametral Pitch and subtract 2.
14	Thickness of Tooth	Diametral Pitch	Divide 1.5708 by the Diametral Pitch.
15	Addendum	Diametral Pitch	Divide 1 by the Diametral Pitch
16	Working Depth	Diametral Pitch	Divide 2 by the Diametral Pitch
17	Whole Depth	Diametral Pitch	Divide 2.157 by the Diametral Pitch

*Diametral Pitch is the Number of Teeth to each inch of Pitch Diameter.

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transmit when the diameter, face, pitch and r.p.m. are given, multiply the diameter in inches by the face in inches by the r.p.m. by the factor corresponding to the pitch, given below:

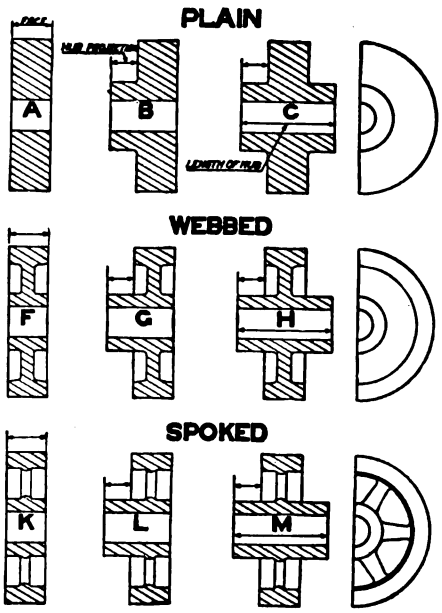
Pitch	Factor	Pitch	Factor
1 in.	0.0018	2½ in.	0.00468
1¼ in.	0.00228	2¾ in.	0.00516
1½ in.	0.00276	3 in.	0.00564
1¾ in.	0.00324	3¼ in.	0.0061
2 in.	0.00372	3½ in.	0.0066
2¼ in.	0.0042	4 in.	0.00756

This table is calculated on a safety factor of 7½ for cast-iron spur gearing. The ratings given are based upon usual steady-load conditions and are not sufficient to care for unusual and heavy intermittent service, which generally requires gears of 50 to 100 per cent more capacity. It is also recommended that the horsepower of the smaller gear of a pair be used.

Gears are made in three general styles: plain, webbed and spoked. As the name indicates, the plain gear is solid and of uniform thickness, except for the hub or central portion, which may or may not be extended out. In the webbed gear the portion between the rim and the hub is made thinner for the purpose of saving weight. In the spoked gear still more weight is saved by employing spokes instead of a solid web, between the rim and hub. Large gears, like pulleys and flywheels, are frequently split or made in halves which are bolted together, to facilitate handling.

Although the formulas previously given refer only to cast-iron spur gears, these may be made of other materials and finished in various ways, depending on the requirements. Thus, for many purposes a gear with molded or cast teeth is fairly satisfactory. In most instances, however, the teeth are cut, which gives a longer-lived, quieter and more efficient gear. Carbon and alloy steel gears, carefully heat-treated, are often employed for special purposes. The strength of such gears is, of course, considerably greater than that of those made of cast iron.

Mortise Gears are sometimes used in cases where noise is objectionable, although they are inferior in strength, efficiency and length of life to properly cut cast-iron gears. These gears are essentially iron wheels provided on the rim with slots



Different styles of gear wheel and hub construction.

into which wooden teeth are wedged. The teeth are made of hardwood, usually maple. The mating wheels are generally of cast iron and should have machine-cut teeth, in order to prevent excessive wear on the wooden, mortise-wheel teeth.

Non-Metallic Gears and Pinions Used for Silent Drives

The increasing use of motor drives and higher speeds for machinery in general has, during the past few years, given great impetus to the development of silent drives, through the use of gears or pinions made of some non-metallic material. Rawhide is extensively used for this purpose, and gears and pinions made from it may be obtained from a number of manufacturers. Rawhide gears and pinions are generally made with brass, cast-iron or steel flanges or end plates. These flanges are riveted or bolted under heavy pressure and usually extend to the top of the teeth, serving, of course, to increase the strength.

High-grade rawhide pinions are usually assumed to have about 75 per cent of the strength of a cast-iron pinion, and when used under the proper conditions will usually give satisfactory service. It is important, however, to avoid the use of rawhide pinions when there is severe reciprocating or intermittent motion against them, nor should they be mated with a cast gear, as the irregular spacing of the teeth and the rough surface will cause rapid wear. Inasmuch as rawhide is animal matter, excessive heat will quickly destroy it, while moisture will cause it to swell and then shrink when dried out. Rawhide gears should, therefore, not be exposed to much heat, and should be kept dry.

Mineral oil should not be used as a lubricant, nor should oil working out of bearings be allowed to get on rawhide gears or pinions. A small amount of hard grease and graphite is the best lubricant to use on rawhide gears.

Pinions made of cloth have also been successfully used. They are made of cloth or cotton filler compressed under hydraulic pressure and tightly held by metal flanges, as in the case of rawhide gears. In addition, there are on the market several makes of gears and pinions formed from special fabrics impregnated with a binder. It is claimed that these are unaffected by oil or water, that they can be substituted for untreated steel, cast-iron, bronze and non-metallic gears and pinions and when properly applied and lubricated will often outlast cast-iron or brass wheels.

Useful as spur gears are for many conditions of service, they nevertheless possess certain inherent characteristics which are undesirable. For example, the teeth come in contact over their entire length at one time and the whole load is first thrown on the end of the tooth. Although this strain is gradually reduced as the teeth mesh more closely, the initial strain is sudden and severe. In the case of spur pinions and gears the drive is practically a series of impacts.

Editor's Note: Acknowledgment is made to the following concerns for assistance in furnishing information and photographs for this and the succeeding article: Boston Gear Works, Norfolk Downs, Mass.; The Chicago Rawhide Mfg. Co., Chicago, Ill.; Christiana Machine Co., Christiana, Pa.; The Cleveland Worm Gear Co., Cleveland, O.; The Falk Corporation, Milwaukee, Wis.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear and Machine Co., Chicago, Ill.; William Ganschow Co., Chicago, Ill.; General Electric Co., Schenectady, N. Y.; D. O. James Manufacturing Co., Chicago, Ill.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Meachem Gear Corporation, Syracuse, N. Y.; New Process Gear Corporation, Syracuse, N. Y.; Niles - Bement - Pond Company, New York, N. Y.; R. D. Nuttall Co., Pittsburgh, Pa.; Philadelphia Gear Works, Philadelphia, Pa.; The Poole Engineering and Machine Co., Baltimore, Md.; Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

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Practical Requirements of

Fuse Protection For Motors

Without Starters or That Drive Heavy Loads Which Are Slow to Accelerate

By WILLIAM E. SEWARD,
Electrical Engineer, American Manufacturing Company, Brooklyn, N. Y.

IT is often difficult to give adequate protection to motors. This is particularly true in the case of small motors which are started by connecting them directly across the line and for all motors which are subject to temporary overloads whether at starting or in running. There are a large number of motors installed under these conditions in the textile mills of the American Manufacturing Company. In the severe service mentioned, if a fuse is installed large enough to pass heavy starting and temporary overload currents, it will be too large to protect the motor. This results in many burnouts. If the fuse is small enough to protect the motor windings, it blows frequently which results in lost time and production. To get rid of this annoyance and expense, various schemes were studied. The plan adopted was to install fuses having a time lag inversely proportioned to the current at which they blow. This did not necessitate the purchase of other new equipment. Six months of operation have proved the plan a very satisfactory one as many troublesome conditions have been eliminated.

Since the writer made the first installation of these fuses, he has applied them to numerous motors. There are a number of small motors in the plant which are thrown directly on the line without control apparatus. Formerly if fuses large enough to pass the high starting current were used, they would not properly protect the motors under running conditions nor against the high current demands of polyphase motors when accidentally running single-phase. In some of the smaller motor installations a double-throw switch is used. One position of this switch has heavy starting fuses, while the other has fuses of the proper size for running. The switch is thrown from starting to running position after the motor is up to speed. Many of these switches are not equipped with a spring device to prevent their being left in the starting position. As a result, switches were very often left connected to the large starting fuses which do not give proper protection. This carelessness in operation was present in spite of instructions posted near the switches. It would be better, in a case of this kind, to employ a switch which could not be left in the starting position. It is not, however, the general custom throughout the country to do this on account of the expense of the special switch.

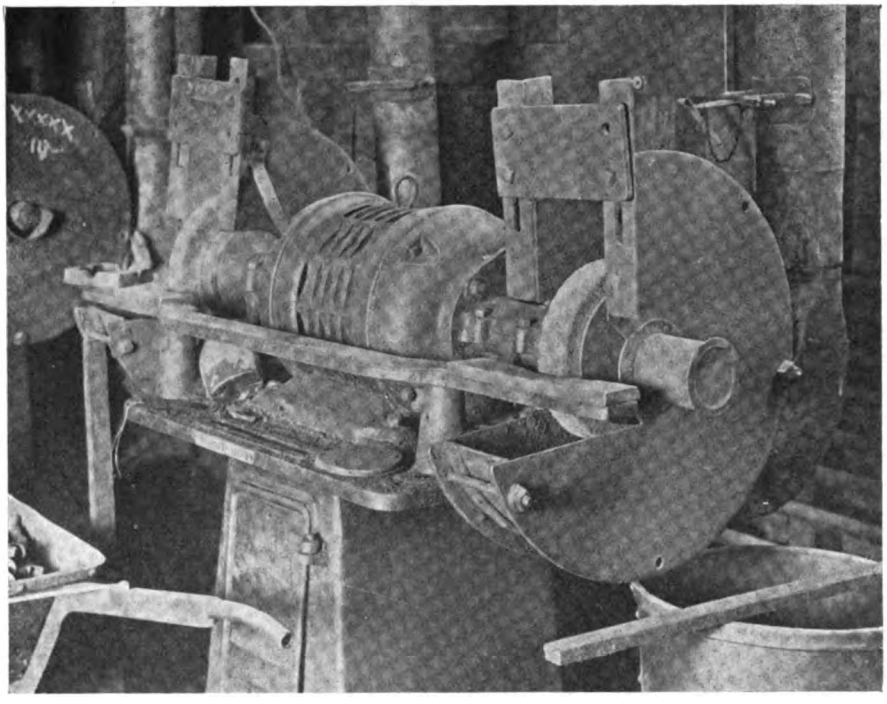


Fig. 1—For protecting grinders a fuse with a time-lag is desirable. This motor draws a heavy starting current but the protection should be such that it will not operate until the motor is up to speed.

IN THIS ARTICLE Mr. Seward tells how he has eliminated motor burnouts caused by overloads and single-phase operation by the use of a fuse having an appreciable time lag which is inversely proportional to the current. He has applied this solution particularly to small motors which have no starting equipment and to large motors which drive a load that is heavy and slow to start. He discusses also the use of smaller branch feeders which a fuse of this kind makes allowable, and the reduction of heating in panel boxes by using a fuse of the characteristics described.

To pass the starting current of these small motors, the fuses must be rated at about 300 per cent of full-load current. If a motor is allowed to run on fuses of this size it has no protection against single-phase trouble or overload. Under full-load conditions, three-phase motors running single-phase will draw between 173 per cent and 200 per cent of full-load current. This is enough to burn out the motor windings and yet it will not blow the large fuses. The current through the one active phase of a delta-connected motor will be even greater than this. If the line current is 173 per cent of the full-load current, the current through the one active phase will be 300 per cent of the current which normally runs through this phase. Two-phase motors when running single-phase un-

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der full-load conditions, will draw between 200 and 225 per cent of full-load current. Consequently, a fuse rated at 300 per cent of full-load current will not blow although the motor will burn out when running single-phase.

In trying out the time-lag fuse with alternating-current motors, it was found that the same set of fuses could be used for both starting and running protection. Table I was constructed for use on these motors. The starting fuses originally employed were rated at two and three times full-load current, while the running fuse was rated at one and one-quarter times the full-load current. It was found that in almost all cases a time-lag fuse rated at one and one-seventh times full-load current was suitable. A fuse of this size gives sufficient time for the motor to come up to speed. At the same time, it gives very close protection for overload and single-phase conditions. The time which will elapse before the fuse blows at starting current is given in one column of the table.

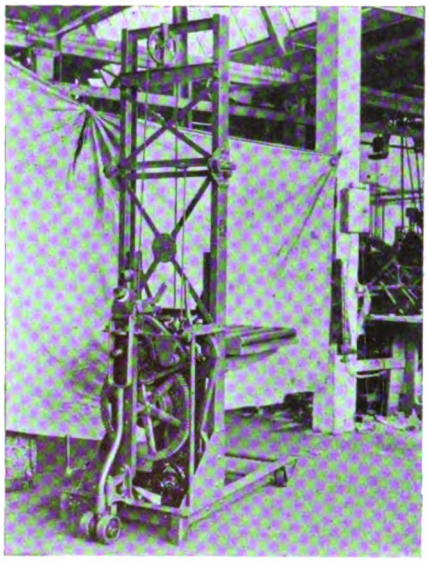


Fig. 2—A tiering machine starts lifting at full load and the protective device must allow for a heavy momentary current.

The fuses were particularly applicable to direct-current motors which had slow-speed heavy-duty starting conditions. Elevators, hoists, pumps, rolls, crushing and grinding machines and compressors are typical of the services referred to. The starting currents are often three times normal, decreasing slowly as the speed increases and reaching normal at full speed. Under such conditions the former fuses were chosen large enough to carry the heavy current required during the slow accelerating period. As a consequence little overload protection was afforded the apparatus by these fuses. In nearly every installation of this kind it was found that a time-lag fuse rated at about 25 per cent overload would give the motor sufficient time to reach normal running speed before the fuse blew. See Table II.

A fuse of this size will protect the motor properly against abnormal running conditions. With the original fuses a size one and one-half times the full-load current was employed. This was too large to give the correct protection.

In putting in new motor installations using the time-lag fuse, it was found that smaller branch conductors could be used than was possible with the old fuses. The reason is that the time-lag fuses could be employed with a lower rating, while the size of conductor is limited by the size of the fuse which protects it. This difference in conductor size is shown in Tables I and II. These give the sizes of fuses of both kinds to be used with various sizes of motors. Corresponding to the fuse sizes, the sizes of wire required are shown.

On lighting circuits there was no advantage in using the time-lag fuse, except where the following conditions were found: In panels where the regular fuses and their connections were so highly loaded that the resulting heat was causing trouble the time-lag fuses were found to reduce the temperature to safe values. Also, the fuses are employed on some lighting circuits which are loaded to capacity with lamps and from which current is sometimes taken temporarily to operate portable electric tools. The starting current of the small tool motors would sometimes blow the lighting fuses. The time-lag fuses were put in to take care of the temporary overload current.

Among the installations which had been giving trouble were twelve groups of 1/30-hp. motors driving humidifiers. Much trouble was

Table 1—A. C. Motor Wiring Data Using Time-Lag Fuses of Sizes Indicated

Hp.	Amp., Full Load	Amp., if running single-phase fully loaded.	Size of Fuse, Amp.			Blowing time of Time-Lag Fuse at Starting Current Seconds.	Wire Size, B. S.	
			Regular		Time-Lag		With Regular Fuse	With Time-Lag Fuse
			Starting	Running	Starting and Running			
220-Volt Three-Phase Motors								
1	3.7	7	10	10	6	8	14	14
3	9.3	16	30	15	12	3	10	14
5	12	21	45	20	15	3	8	14
7½	22	38	60	30	25	3	6	10
10	25	43	65	30	30	3	6	8
15	38	66	80	50	45	8	4	6
20	52	90	100	65	60	16	2	4
25	64	100	130	80	75	16	1	2
30	77	133	160	100	90	30	0	2
40	107	185	220	135	125	30	00	0
50	118	204	240	150	135	26	000	00
440-Volt Three-Phase Motors								
1	1.5	3	10	5	5	10	14	14
3	4.25	8	15	6	6	10	14	14
5	6.5	11	20	10	8	3	12	14
7½	10	17	30	15	12	3	10	14
10	13	23	35	15	15	3	10	14
15	20.3	35	50	25	25	10	8	10
20	24	42	65	30	30	10	6	8
25	30	60	70	40	35	12	6	8
30	36	63	80	50	45	20	4	6
35	42	73	90	60	50	24	2	6
40	47.5	82	100	65	60	42	2	4
50	62	107	125	80	75	42	1	4

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Table II—Wiring Data for D. C. Motors Which Start Under Heavy Loads

Hp.	Amp. Full-Load	Size of Heavy-Duty Starting and Running Fuse Amp.		Wire Size B. & S.	
		Regular	Time-Lag	With Regular Fuse	With Time-Lag Fuse
0.5	2	4	4	14	14
1	4	6	5	14	14
2	8	12	10	14	14
3	12	20	15	12	14
4	16	25	20	10	12
5	19	30	25	8	10
7½	28	40	30	6	8
10	38	60	40	4	6
15	56	85	60	1	4
20	75	115	85	0	2
25	94	145	100	00	1
30	113	170	125	000	0
40	150	225	165	0000	000
50	188	280	200	300,000	200,000

caused by single-phase operation of these groups resulting from the blowing of one fuse of a group. The motors were connected in groups of sixteen and seventeen, only one switch and one set of fuses being used on each group. The starting current for a group was so high that a standard fuse which would pass the starting current would not give any protection on single-phase operation.

Altogether there are 200 motors in twelve groups. The motors are rated 220 volts three-phase. The running current drawn by a group of seventeen motors is 2.7 amp. and the load of one group is about ½ hp. One single-throw oil switch is used to throw the 200 motors directly across the line. Under this condition the starting current of a group of seventeen is 17 amp. Individual fuses were not employed on the motors as a fuse large enough to pass the starting current would not give adequate protection on overload or single-phasing. Each group was protected by standard 20-amp. fuses. This was the smallest commercial size which would pass the starting current. However, when one of these blew, as often happened, the motors drew a single-phase current of 10.2 amp. Often the motors ran under this condition until one or more of a group was seriously burned. The 20-amp. fuses gave no protection at this current.

Fig. 3—For starting a long shaft like this the motor should have time-lag protection.



Among the solutions considered was the installation of a phase-failure relay and automatic circuit breaker in each circuit to open it under single-phase or overload conditions. This was an expensive solution and therefore other methods were examined. Another solution would have been installing double-throw switches in each branch. Such switches throw the load directly on the line for starting and transfer it to the fuses for running. Such a switch fused with 6-amp. running fuses would have answered the purpose. This switch, however, must be so constructed that the blades cannot be left in the starting position. This adds the complications of a spring or some such arrangement. Switches of this kind are on the market.

Instead of buying these switches, however, to replace those already in use, the time-lag fuse was tried out in the old fuse clips. The operation with this arrangement has been perfectly satisfactory. There have been no burnouts or other trouble since the fuses were put in about six months ago. A 6-amp. time-lag fuse was used. This fuse, according to tests made by the Electrical Testing Laboratories, will blow in about two seconds at a load of 17 amp. which is the starting current, see Table III. This gives plenty of time for the motors to come up to speed. At the same time in case of failure of one fuse the single-phase current of 10.2 amp. will blow the other fuses in eight seconds, which is quick enough to prevent damage to the motors.

As the removal of trouble had been so simple in the case just related, the same remedy was tried on several other motors having bad starting conditions. The motor in one instance is a 3-hp., 220-volt, direct-current machine which drives a water pump and is automatically controlled by the water level in a tank. Both motor and controller gave considerable trouble. The controller is of the magnetic lockout type and the motor draws 250 per cent current at starting as it starts heavily loaded. This starting current is 27 amp. for four seconds. The original fuses were of 25-amp. rating in order to stand this starting current. However, they gave practically no protection for most

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overload conditions as the full-load current is only 11.8 amp. As a result the motor was burned out twice and the controller was badly injured once. In addition, blowing of the fuses often caused the pumps to stop when they should have been supplying water, a shortage of which might be dangerous.

Consequently the old fuses were replaced by time-lag fuses rated at 15 amp. This rating gives adequate protection from occasional overloads and also allows the starting current of 27 amp. to pass for four seconds without blowing. Since these fuses were put in there has been no trouble.

Another case where much trouble had been experienced was that of a 3-hp., 220-volt, two-phase, 60-cycle motor driving a tiering machine. The starting current on this motor is 35 amp. for one second while the running current is 6.9 amp. at full load. The original fuse was rated at 45 amp. This was replaced by a 25-amp. fuse having the time-lag feature. This fuse allows a starting current of 50 amp. for three seconds. Since its installation the troubles which were formerly frequent have stopped.

Another motor driving a water pump had been giving trouble. This was a 5-hp., 220-volt, two-phase, 60-cycle motor with a full-load current of 11.5 amp. On starting the pump the motor drew 60 amp. for three seconds. A 50-amp. fuse had been used and this blew frequently. It was replaced with a 30-amp. time-lag fuse which stopped the trouble. This 30-amp. fuse will stand 60 amp. for three seconds—Table III.

Smaller Branch Feeder Permissible

A way in which a smaller branch motor feeder may be used in conjunction with these time-lag fuses is shown in the case of a large three-phase motor driving a finishing machine. The particular motor mentioned is typical of a large number of motors in this plant. It is phase-wound and the protective equipment consists of an oil switch with inverse time-limit overload relay and no-voltage protection and an ammeter. The motor is controlled by a drum switch and resistance in the secondary. A safety type disconnecting switch with fuses is mounted on a column near the point where the motor feeder taps the main. The motor is phase-wound and is rated 35 hp., 440 volts, three-phase, 25 cycles, 42 amp. The starting current is 80 amp. to 110 amp. for variable lengths of time depending on the load. The original fuse was of 100-amp. capacity. It was replaced by a time-lag fuse which will pass 130 amp. for twenty seconds. With this fuse a smaller conductor might be used for the branch-wire than with the 100-amp. fuse. For the 100-amp. fuse a wire of No. 2 gage would be used. (This would be a No. 3 gage conductor according to Rule No. 8 c-3 of the National Electrical Code, but No. 3 is not usually available and therefore No. 2 would be used.) With the 65-amp. fuse a No. 6 conductor may be used.



Fig. 4—A fuse link which has a time-lag. The two beads on the copper strip are composed of cadmium, tin and antimony.

Overheating of Safety Panelboard Eliminated

While the writer was examining these fuses it was found that they remain considerably cooler in operation than fuses previously used. This led to their trial in a number of eight-circuit dead-front panelboards which overheated excessively. All the circuits in these boards were carrying from 103 to 114 amp. though their capacity was only 100 amp. each. The heat given off by the heavily loaded fuses was largely retained by the tight steel panel cases and slate barriers. The metal parts of the circuits became overheated to such an extent that fuses blew frequently. Some of the switch bridges also were injured and had to be replaced. To stop the damage being done by the excessive heat, the covers were removed from the panelboards to be left until a remedy was found. A simple solution of the problem would have been the addition of one independent circuit to each panel so arranged as to relieve the fully loaded circuits. That solution would have been rather expensive. The substitution of larger fuses would have been dangerous because one set of fuses might carry too high a current if the box had become cold either from running all night without load or when all other fuses were carrying light loads.

While looking for a remedy for this trouble the writer discovered the low (*Continued on page* 119)

Table III—Time of Blowing, Temperature and Voltage Drops of Time-Lag Fuses

Per Cent of Rated Current	250-VOLT FUSES*				600-VOLT FUSES*			
	30-Amp	60-Amp	100-Amp	200-Amp	30-Amp	60-Amp	100-Amp	200-Amp
	Time of Blowing							
	Min.Sc.	Min.Sc.	Min.Sc.	Min.Sc.	Min.Sc.	Min.Sc.	Min.Sc.	Min.Sc.
125	115:15	113:00	109:30	110:00	116:00	113:00	106:00	.....
140	4:19.6	6:00	10:15	12:00	4:15	5:45	9:15.6	17:00
150	50.9	1:37	4:00	4:30.5	42	1:54	3:29	5:40.3
175	7.6	16	26	41	17	24	56.1	1:13.6
200	3	7	10	15	10	12	21.1	30.4
250	2.2	1.8	.....	4.7	3.3	5.6	8.1	12.6
300	0.8	1.8	2.5	3	2.5	5	4.9	7.4
	Temperature, Degrees Centigrade							
100	87	82.6	52.1	49.8	60.5	71.8	44	40.8
110	93.8	88.5	56	52.9	68	79.5	47.2	46
115	102.9	97	61	57.2	75.6	87.5	51	50.5
	Volts Drop							
100	0.1920	0.1264	0.1179	0.1039	0.1878	0.1744	0.1402	0.1203
110	0.2251	0.1512	0.1396	0.1249	0.2264	0.2030	0.1648	0.1433
115	0.2606	0.1809	0.1528	0.1326	0.2508	0.2309	0.1807	0.1568

*These fuses are made in ratings as low as 3 amp. and the fuses under 30 amp. in size follow fairly closely the figures given above for the 30-amp. fuses.

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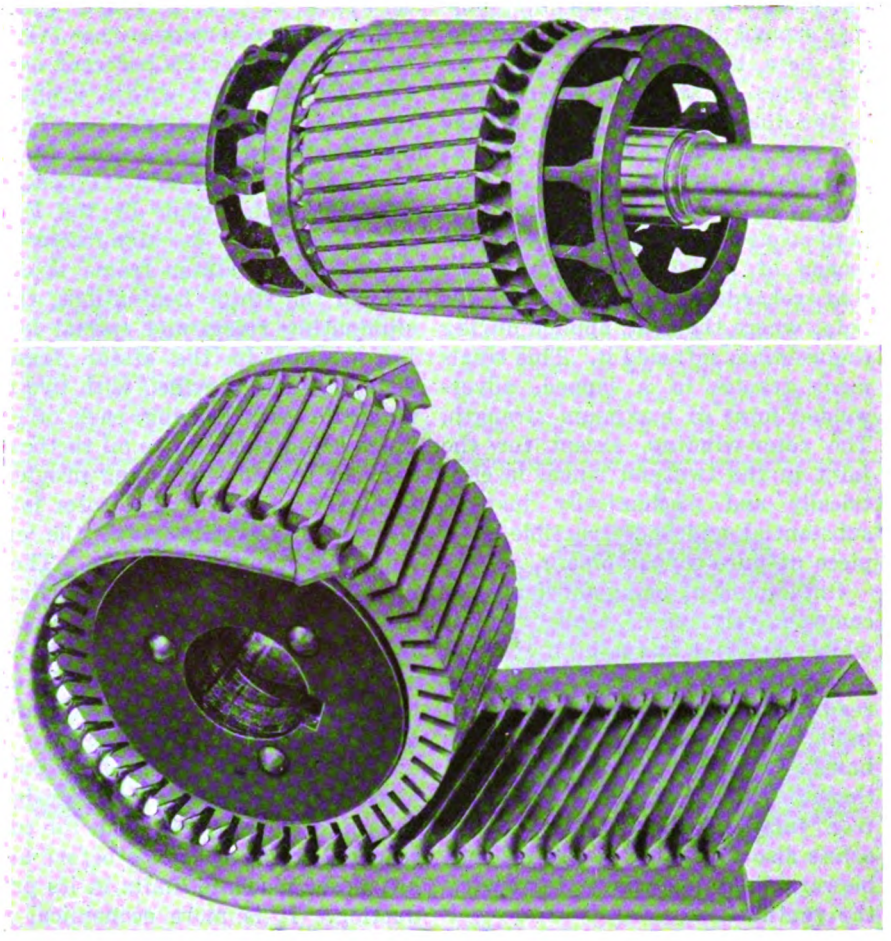
SOME OUTSTANDING developments were made during 1922 in electrical and associated mechanical equipment. In this article details are given covering the construction and operation of new devices from the standpoint of their application to works operation and maintenance.

A Review of the New

Products Produced In 1922

Of Interest to Operating and Maintenance Men in Industrial Works

By E. H. HUBERT,
Associate Editor, Industrial Engineer



This rotor has a one-piece winding consisting of an integral sheet of copper punched and formed by a special mechanical process and machine wrapped around the rotor core with the copper bars expanded into the core slots by swaging. The two end rings are silver welded at one point. It is used in the new L. A. motors manufactured by the Louis Allis Company, Milwaukee, Wis.

AMONG the 1922 developments in equipment used by operating and maintenance departments of industrial works, there are some outstanding features and many other details which, although they relate to smaller equipment, are nevertheless of equal interest in improving the operation of electrical and associated mechanical systems. Among the most important advances are those made in motors, both synchronous and induction. The value of the electric steam generator under many conditions is becoming more appreciated. A record has been made in the size of steel melting furnaces. Electric ovens are being successfully applied to more processes. Control for paper mills has been simplified and perfected. Rolling mill control has been improved. Among the smaller equipment developed are motor starters, distribution and wiring appliances, repair and construction machinery and tools. Material-handling equipment has also made forward strides, as indicated on page 41 of the January issue under the title, "Better Methods for Handling Materials."

Among motor developments is a synchronous motor designed to start at full load without the use of a clutch, several improvements in squirrel-cage motors, a self-starting polyphase induction motor, and several small motors. The new synchronous motor which does not require a clutch for starting under a heavy load has been developed by the General Electric Company. The motor is so constructed that it is possible when starting to bring the armature (which is normally the stator) up to synchronous speed, regardless of the load. The load is connected to the rotor, which remains stationary until the stator has come up to speed. Then the field is applied in the ordinary way. The rotor is gradually brought up to speed by applying a powerful band brake to the stator. The brake is applied gradually and the driven machine is brought up to speed without a shock. The stator is then held stationary by the band brake and the motor functions as an ordinary synchronous motor. It is claimed that this motor can develop a starting torque of from 150 per cent to 300 per cent of normal torque throughout the entire starting period. This motor is illustrated in *D* of Fig. 1.

In induction motors the big improvements have been a new rotor construction in one machine and in others, sturdier shafts, frames, and brackets, increased feed of oil to bearings, improved ventilation, more durable installation and enclosed motor terminals. The companies that have brought out new squirrel-cage motors are the Louis Allis Company, Milwaukee, Wis.; Electric Controller & Manufacturing Company, Cleveland, Ohio, and the Wagner Electric Manufacturing Company, St. Louis, Mo. The three motors are illustrated in *A*, *B* and *C* of Fig. 1. The Louis Allis Company has produced a motor with a new squirrel-cage rotor construction. In this motor, the entire winding of the rotor consists of an integral sheet of copper, punched and formed by a special mechanical process. This

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one-piece winding is machine-wrapped around the rotor core, the copper bars being expanded into the core slots by swaging, as indicated in the illustration at the top of page 89. The single joint which extends through the two end rings, is silver welded, after which the metal at both connections is processed by means of a contracting operation that rehardens the copper at the point where the heat, applied during the welding, softened it. This treatment results in a lapped, silver-welded joint of maximum strength. The rotor-winding, except for the joint in the two end rings, is electrically and mechanically just as substantial and indestructible as a piece of pure copper pipe.

On account of being fabricated of comparatively thin copper stock, which material has a high thermal conductivity, this rotor winding readily conducts the heat generated in it toward the ends of the rotor bars where this heat is dissipated through the action of the malleable iron fans. The rotor bars themselves also constitute a very efficient blower, thus materially increasing the ventilation.

The rotor core, as a self-contained unit, may be pressed on and off the shaft readily as it has a straight keyway. Otherwise it is largely conventional except that it employs open slots without the usual overhanging tooth tips. Experience has shown that so long as a suitable relation is maintained between the air gap and slot width, the performance does not suffer as regards power factor and efficiency, and that a rotor core of this construction, with a suitable winding results in exceptionally high starting and running torques. These abnormally heavy starting and running torques have led the manufacturers to increase the shaft size over and above the usual practice for a given rating which, in combination with the liberal bearings, fabricated from a phosphor-bronze, insures exceptionally long life in service.

While great stress has been laid on the mechanical ruggedness of this new line of motors, the electrical characteristics have received equally careful attention. In addition to the exceptional starting and running torques, all motors are guaranteed to carry their full rated load continuously with a temperature rise not exceeding 40° C., and after their ultimate temperature has been reached, to carry 25 per cent overload for two hours with a temperature rise not exceeding 55° C. These motors are made in standard industrial sizes, voltages and frequencies.

In the motor made by the Electric Controller & Manufacturing Company, the stator frame is cast around the stator laminations, thus eliminating rivets and special locking devices in the stator frame. This motor is provided with two oil rings for each bearing, each of the rings being sufficient to oil the bearing, the second ring being provided as a safety feature. The rotor is of rugged construction with the end rings cast onto the rotor bars. These rings are heavy enough to stand overload currents without undue heating. The bearing part of the shaft is of large size, with the extension for pulleys or gears of standard dimensions.

The Wagner motor is a new polyphase, heavy-duty, 40-degree design. It is lighter in weight than for corresponding ratings made before and has closer machine limits in its production. It is more economical in the use of materials employed and takes in more air and is, therefore, better ventilated and an improved design from all electrical and mechanical standpoints.

Another induction motor which provides improved ventilation has been developed by American Electric Motors, Inc., Milwaukee, Wis. This motor is entirely closed and has outlet and inlet pipes for air circulation. It is intended to be used in a plant where the air is not clean and to draw in clean air from outside. Ball bearings are used in this motor.

A self-starting polyphase induction motor in capacities of 5 hp. to 30 hp. has been developed by the Fidelity Electric Company, Lancaster, Pa. It is said that this motor starts at 100 per cent of full-load torque.

Fractional-horsepower split-phase induction motors have been brought out by the Reynolds Electric Company, Chicago, Ill., and a fractional repulsion-start induction motor has been developed by the Dayton Fan and Motor Company, Dayton, Ohio. The France Manufacturing Company, Cleveland, Ohio, has developed a fractional-horsepower synchronous motor.

The Master Electric Company of Dayton, Ohio, has in production a new motor which is made in sizes from 1/3 to 1½ hp. A distinctive feature of the new motor is the symmetrical frame. The frame dimensions on the commutator end are all identically the same as on the shaft projection end. This new motor has interchangeable frames for alternating and direct current. Among the other features are the compact short-circuiting device; the removable, self-aligning, phosphor bronze bearings, and the dual-wick oiling system.

The complete line of Master motors is from ⅛ to 1½ hp. alternating-current, single-phase, repulsion induction motors; polyphase induction motors and compound-wound direct-current motors; and up to 2-hp. high speed. The repulsion-induction type motor is of exceptionally high starting torque with low starting current consumption. They are designed to start extremely heavy overloads with so slight drop in line voltage that the annoyance of light flickering is practically eliminated. They also operate on heavy overloads and under low adverse voltage conditions.

Improvements in Control Equipment

Notable developments have been made in control equipment for paper-mill drive, printing presses, steel-mill and other rolling mills, metal and woodworking plants, oil-well drives, and ice-making equipment. There has also been a number of new motor starters.

An improvement in paper-machine drive has been made by the General Electric Company that reduces greatly the size of the control apparatus. The principle of the voltage regulator is applied for the control of each section of the paper machine; so that any change in load, voltage or speed instantly applies a correction. This regulator type of control, like the control brought out about two years ago, is dependent upon synchronous motors operating in parallel for maintaining a constant relation of speed between the main driving motors. But the regulator type allows the use of very small synchronous units in place of units about 20 per cent of the capacity of the main motors. The control equipment consists of a ⅛-hp. synchro-

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nous motor driving a cone pulley 4 in. in diameter and in length connected by belt to another cone of the same size. The relative speed of the two cones may be changed by shifting the belt. The second cone carries a small disk with a number of contacts. Another disk of the same size is attached to the main drive motor on the paper machine. These disks rotate in the same direction, the contact points making and breaking contacts very rapidly when there is a slight angular displacement between the two disks. The making and breaking of the contacts respectively short circuits or inserts a resistance in the direct-current motor field. The result is a fixed speed on this direct-current motor.

For the control of large printing presses, a new line of controllers for both alternating and direct current has been developed by the General Electric Company. This involves the use of a simpler and more substantial pilot motor and master switch and employs an improved type of operating contactor. Three groups of these controllers have been installed

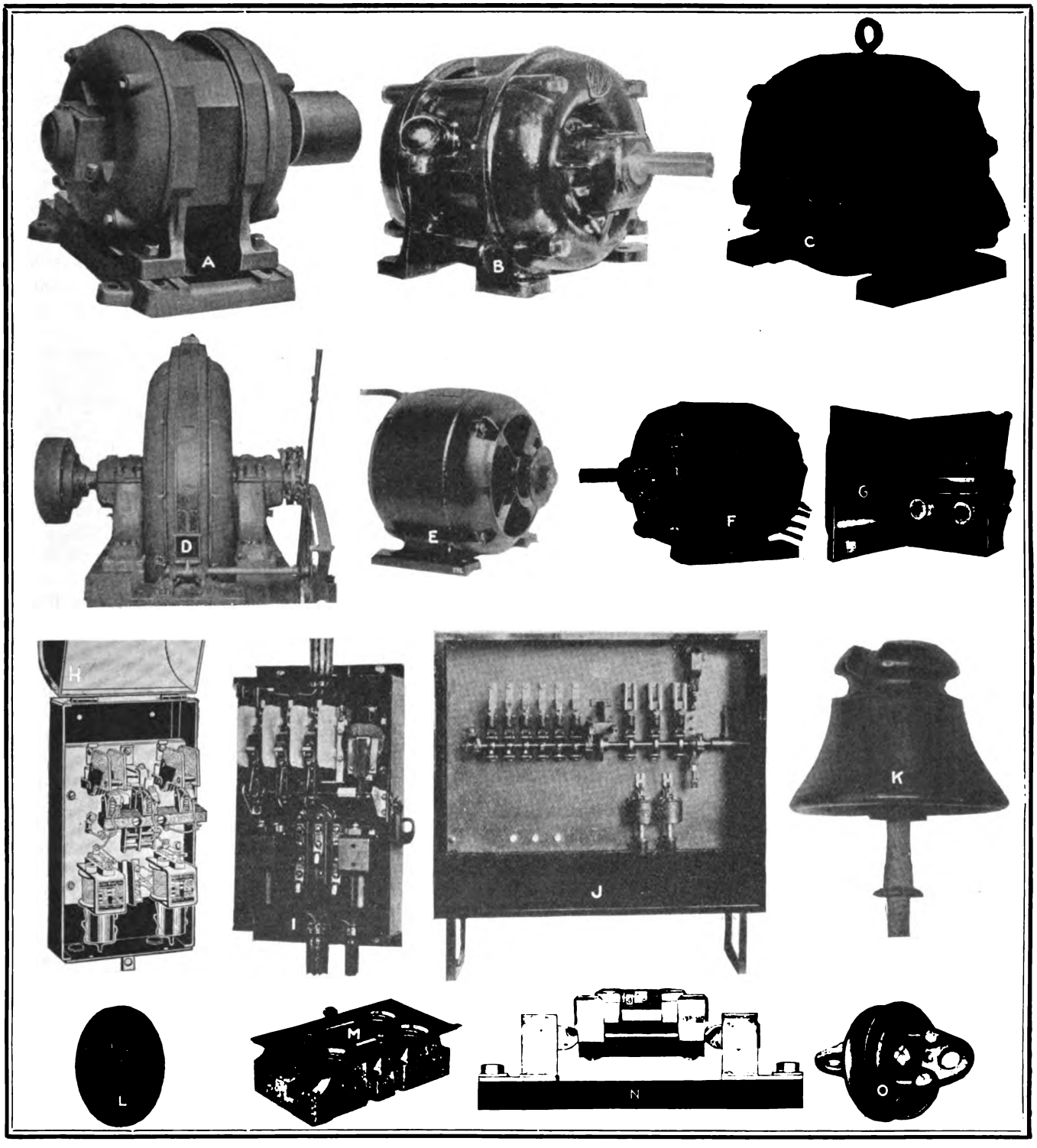


Fig. 1—New developments in motors, control and circuit-devices.

A, *B* and *C* are three new squirrel-cage induction motors. Ruggedness, large shafts, durable insulation, better oiling arrangements and improved rotor construction are among their features. At *D* is a synchronous motor whose "stator" revolves on starting. It is gradually brought to rest by means of a brake. In the meantime the rotor has increased in speed from zero to full speed. This arrangement allows starting under heavy load without a clutch. At *E* and *F* are two fractional-horsepower motors. Three motor starters are shown in *G*, *I* and *J*. At *H* is an across-the-line motor-starting switch. In *K* and *O* are, respectively, a 6,600-volt and a 4,400-volt insulator especially adapted for factory conditions such as dust, fumes, smoke, etc. A device for making a wall or ceiling outlet is shown at *L*. At *M* is a fuse cutout and at *N* is a "reducer" to allow a small fuse to be used in large clips.

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in the new building of the *Public Ledger* in Philadelphia to operate a twelve-unit press.

Several interesting developments in mill drives have been reported by the Westinghouse Electric & Manufacturing Company. These include a new system of paper calender drive and control that involves the use of a commutator-type frequency changer. The calender is driven by a wound-rotor induction motor. The motor operates under running conditions from a bus giving a standard frequency, but when threading-in it is connected to a bus giving about six cycles per minute, supplied by the frequency changer. This arrangement eliminates a separate threading-in motor which has been used in the past.

Several installations on rolling mills have been made in the past year, involving improvements in control and arrangement of equipment. A control method for motor-driven, cold-rolled-strip reels has been worked out by the Westinghouse company. The problem in this application is to maintain a constant tension in the strip being delivered from the mill and the various conditions of mill speed and effective diameter of the reel. In the plan worked out a generator driven from the last stand of rolls supplies power to the motor which drives the reel. A voltage regulator controlled by the armature current of the motor is connected across a resistance in the field of the motor. This regulator maintains the motor current constant, thus keeping the torque of the motor at a fixed value which results in the same pull being exerted on the strip at all times, with a given setting. An electrically driven rod reel has been put in operation during the past year in a mill where it is necessary that one of the reels follow almost exactly the speed of the last stand. The delivery speed of the mill is sometimes as high as 3,200 ft. per minute; therefore, a slight error would result in a large amount of slack or would pull the rod in two. A small alternating-current generator is driven from the main mill motor and another by a 100-hp. reel motor. These two generators operate a mechanical differential which remains stationary as long as their speeds are the same. When the speed of one or the other of the pilot generators changes, the differential rotates and operates the contact of a vibrating relay which increases or decreases the field on the reel motor. It has been found possible to hold the speed very accurately with this equipment. The Westinghouse company has developed a system of control for use in connection with coke-pushing machines and ladle cranes when two or more motors are used, of which only one operates at a time.

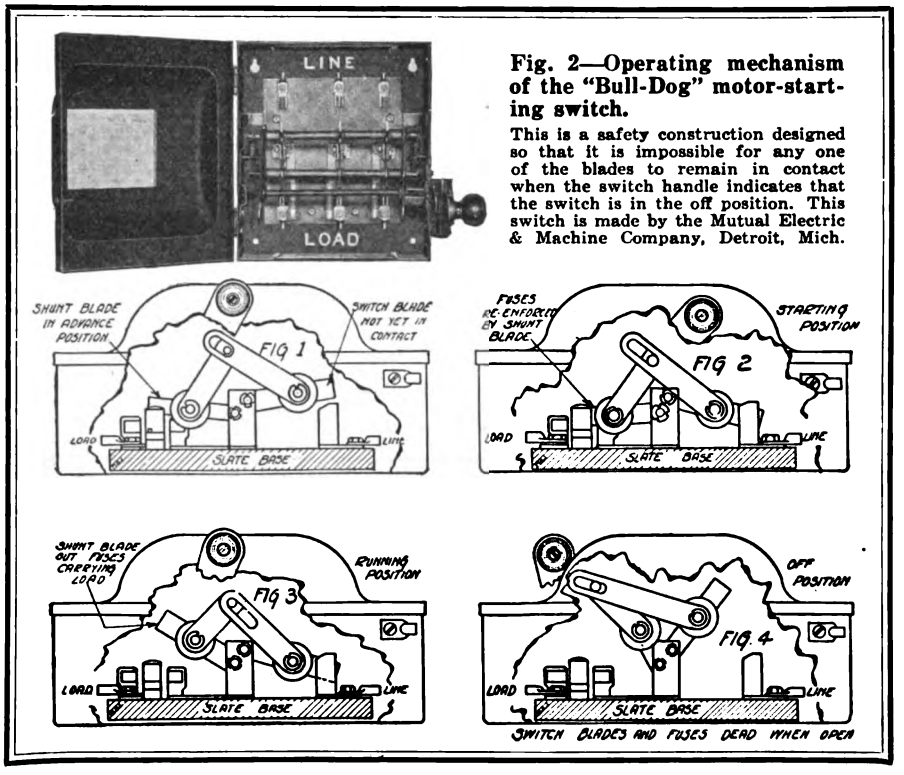


Fig. 2—Operating mechanism of the "Bull-Dog" motor-starting switch.

This is a safety construction designed so that it is impossible for any one of the blades to remain in contact when the switch handle indicates that the switch is in the off position. This switch is made by the Mutual Electric & Machine Company, Detroit, Mich.

In the woodworking industry an interesting multiple control has been developed by the Westinghouse company. This is used on a molder which requires four motors for the cutting head and a four-speed motor for the feed, which develops 5 hp. on all four speeds. Instead of using an individual auto starter with automatic control, a special control was designed for all five motors and mounted in one common casting. The controllers are of the drum type. The overload relays are so connected that an overload on any one motor shuts down the entire machine. There is a tendency in both woodworking and metalworking machines toward the use of direct-connected motors requiring speeds above 3,000 r.p.m. To obtain these speeds, induction frequency changers are used for getting a speed up to 15,000 r.p.m.

Among the starting devices which have been developed is the resistance-type starter made by the Sundh Electric Company, Newark, N. J. This starter is made for both hand and automatic operation. It throws a resistance in the primary circuit of an induction motor in balanced steps. This starter is illustrated in *J* of Fig. 1.

The Allen-Bradley Company, Milwaukee, Wis., has brought out an improved push-button starting switch for squirrel-cage motors. This is an enclosed across-the-line switch which provides overload protection and low-voltage protection and has arc shields and blowout coils to prevent flashovers. Copper-to-copper rolling contacts are provided with stiff pressure while in contact to insure adequate capacity under all loads. The contactor arms are mounted on a single crosspiece attached to the clapper arm and the construction is such that it results in a quick-acting clapper. This starter is designed for alternating-current motors up to 10 hp. and is shown in *H* of Fig. 1.

The Industrial Controller Company, Milwaukee, Wis., has also put out, for small alternating-current motors, an across-the-line starter which has push-button control. This starter has under-voltage protection, over-voltage protection and phase-failure protection. It is built in three sizes which will give from ½ to 7½-hp. range for 110 to 550 volts. A three-pole, 30-amp., 220-volt hand-operated safety motor-starting switch has been put on the market by the Union Electric Manufacturing Com-

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pany, Milwaukee, Wis. This switch is enclosed in a steel box.

A motor drive and automatic switch for typesetting machines has been put on the market by the Cutler-Hammer Manufacturing Company, Milwaukee, Wis. The feature of this control is that the motor is automatically stopped after a predetermined time if no work is being done on the typesetting machine.

The Monitor Controller Company, Baltimore, Md., has developed enclosed starters for motors which consist of a small circuit-breaker and terminal limit relays that provide no-voltage, overload and single phasing protection. The starter is designed for location near the motor so that local temperature conditions affect both.

A new safety motor-starting switch known as the "Bull Dog" has been brought out by the Mutual Electric & Machine Company, Detroit, Mich. The construction is shown in Fig. 2. Tests were conducted in which the rotor of a 7½-hp., 40-degree, 230-volt, a.c., 3-phase, induction motor was blocked so that it could not move, and a 30-amp., 250-volt, 3-pole switch was thrown on and off repeatedly, showing a reading on the ammeter of from 100 to 130 amp. The manufacturers claim that the switch successfully withstood this test in every respect, and that it was in first-class condition after the test was completed. This switch is of rugged construction and, as shown by the test, was built to stand extreme conditions.

Another across-the-line starter has been developed by the Trumbull Electric Manufacturing Company, Plainville, Conn. This is of the enclosed safety-switch type and is made for motors of not over 5 hp. and for 110 to 550 volts. This starting box has inverse-time protective fuses for overload protection. It is shown in *G* of Fig. 1.

Equipment for automatically reclosing a circuit after interruptions on 200- or 600-volt direct-current circuits has been developed by the General Electric Company. This equipment is designed especially for mine installations, for circuits feeding hoists, cutting and drilling machines, and the like. In case of an overload on a circuit protected with this equipment the protected circuit is opened and is closed again only when

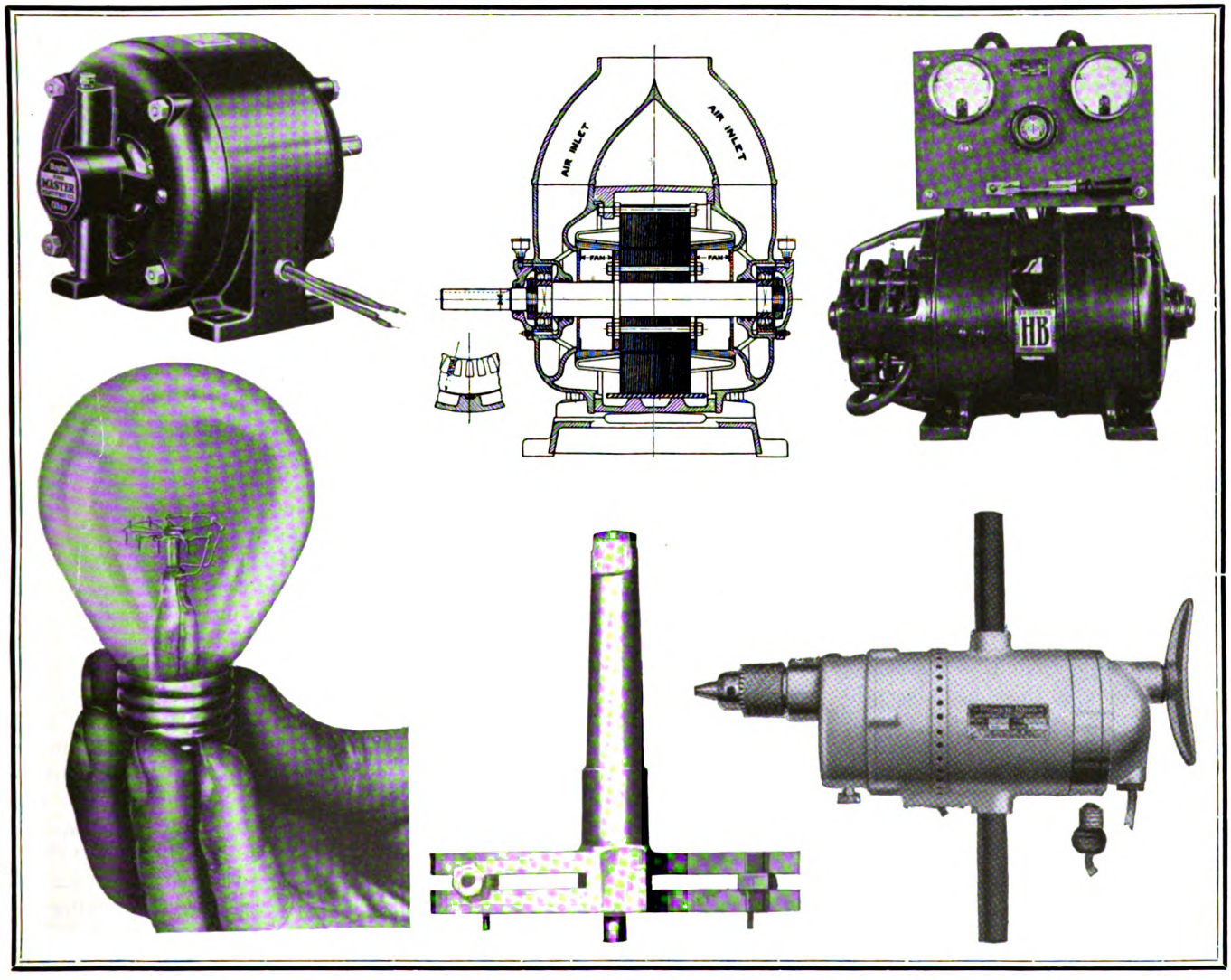


Fig. 3—Three new motors, the mill-type lamp and two tools.

Reading from left to right in the top row, the first motor is a new design made by the Master Electric Company, Dayton, Ohio. It has interchangeable frames for alternating and direct current and is built in sizes from ⅛ to ½ hp. The second motor is made by the American Electric Motors, Inc., Milwaukee, Wis. This is a ball-bearing, self-ventilating design for use where a completely enclosed motor is required. The third illustration in the top row is a constant potential battery-charging outfit made by the Hobart Brothers Company, Troy, Ohio. The first illustration at the left in the bottom row is the mill-type lamp now made in standard sizes of 25 and 50 watts for 115 volts, and 50 watts for 230 and 275 volts. This lamp is made by a number of the lamp companies. The middle illustration in the bottom row is a drill press cutter for making holes in sheet metal, fiber and the like and is made by Paul W. Koch & Co., Chicago, Ill. The portable drill shown at the right in the bottom row is made by Jones, MacNeal & Camp, Warsaw, Ind. It is a sturdy design with two speeds and full ball bearings, operated by a motor of liberal rating.

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the fault is cleared off the line. The automatic operation eliminates delays that might arise from the necessity of reconnecting the load by hand.

For use in accurate pressure, vacuum and thermostatic control a new type of mercury-contact switch has been developed by the Federal Gauge Company, Chicago, Ill. It consists of a glass tube containing mercury, which is brought into contact with the control wires when the tube is put in a certain position. These tubes are made in single-circuit and three-way designs. They will operate at 10 amp., 110 volts, or 5 amp., 220 volts. The same type of switch is also supplied in a smaller size for relay operation.

A switch which is automatically controlled by a remote thermostat has been developed by the Minneapolis Heat Regulator Company. This switch is designed for temperature control on electrical heating units, refrigerating apparatus, automatic oil burners, and the like. It is capable of handling alternating current at 110 volts and 20 amp. The operation of the switch depends upon a 7½-volt relay which is operated by the thermostat; the relay in turn closes the circuit on a 110-volt closing coil.

A timer for automatically operating a signal at the end of a predetermined time is now being made by the Stromberg Electric Company, Chicago, Ill. It is designed for use in manufacturing processes where strict account must be kept of time, such as heat treating, enameling, and so forth. The instrument does not contain a clock mechanism, but is operated by a synchronous motor. At any time the timer indicates how long the process has been in operation and how much longer it will continue until a signal is given.

Equipment Used in Distribution and Wiring

For use on distribution systems of industrial plants there have been developed during the last year circuit-breakers, safety switches, insulators, fuses, flexible conduit and fittings.

Wide application has been made of an enclosed circuit-breaker of small size by The Cutter Company of Philadelphia, Pa., under the trade name of "Urelite." This circuit-breaker is designed to do what fuses are intended to do and combines protection for the circuit with safety for the operator. It can be readily adjusted to any desired current within a wide range and when once set the operation thereafter is constant and invariable. This breaker is operated by an insulating handle mounted on the outside of the box.

A line of totally enclosed circuit-breakers has been brought out by the Roller-Smith Company, New York City. These breakers may be had with plain overload and with under-voltage and shunt trip as desired. They are made for 250 volts and 500 volts. One of the types manufactured cannot be closed on an overload. The capacities are from 5 amp. to 200 amp. A safety switch for across-the-line starting at 250 and 500 volts has been brought out by the Z. & H. Manufacturing Company, Chicago, Ill. It is made with two, three and four poles.

Two insulators designed especially for low-voltage lines such as used in industrial concerns have been developed by the R. Thomas & Sons Company, East Liverpool, Ohio. One of these is the "Baby-Link Type," which is a small design of the well-known Hewlett insulator. This insulator, which is shown in Fig. 1 at *O*, is designed for 2,300 and 4,000-volt lines and for guy and span construction. Its mechanical strength is 6,000 lb. The other insulator is of the pin type. It is for 6,600 volts and under and is recommended for service where salt spray, fog, dust, smoke or fumes tend to coat the surfaces. It is illustrated in *K* of Fig. 1.

Several new fuses have been brought out. A. L. Lewis Company, Canton, Ohio, has developed a fuse plug which shows a small red flag underneath the mica as soon as the fuse blows. The Westinghouse Electric & Manufacturing Company has brought out a line of renewable fuses of the cartridge type. This fuse has a bare link of the drop-out type. The feature of the fuse is the method of getting rid of the hot gases which pass through perforated washers at each end, arranged to give a long and broken passage. The General Electric Company has designed a plug fuse in which no solder is used. The Southern Electric Manufacturing Company, Bristol, Tenn., has placed on the market a line of cartridge and plug fuses. The Trico Fuse Manufacturing Company, Milwaukee, Wis., has put out a powder-filled fuse which is built of fiber, having no porcelain in its makeup. It is claimed that the fuses are very accurate because a restricted link is used in place of the ordinary fuse wire. The makers claim that these fuses weigh only 33 lb. per 1,000, packed for shipment.

A fuse reducer which will allow a fuse of small rating to be placed in fuse clips designed for a fuse of larger rating has been made by the Plainville Electrical Products Company, Plainville, Conn. This reducer is illustrated in *N* of Fig. 1. Dead-front plug-fuse cutout bases have been developed by the Bryant Electric Company, Bridgeport, Conn. One of these is shown in *M* of Fig. 1. A device designed to pull out and replace the closed types of fuses without danger to the operator has been put on the market by the Waterbury Fuse Puller Company, Waterbury, Conn. It will handle fuses of practically any size.

A flexible armored cable with a flat cross-section has been developed by the National Metal Molding Company, Pittsburgh, Pa. The chief advantage claimed for this molding is that it can be readily covered by the thickness of plaster commonly used on brick and tile surfaces. Fittings made specially for use with this oval cable are also made. By means of a special connector the oval cable may be secured to round knockouts in ordinary boxes. A bushing for fastening ½-in. conduits in a ¾-in. knockout is now made by the Adapti Company, Cleveland, Ohio. The Chicago Fuse Manufacturing Company, Chicago, Ill., has placed on the market a shallow sectional switch box specially designed for use in thin partitions. It is 1½ in. deep overall, 3¾ in. long and has a ½-in. knockout at each end. The Arrow Electric Company, Hartford, Conn., has developed a shallow push-button switch. This switch is only 1 in. deep and is made in both the straight push and the toggle types. A fitting for use on 2½-in. and 3-in. conduit where wires are brought into a building through conduit has been brought out by the Killark Electric Manufacturing Company, St. Louis, Mo. This device will fit either vertical or horizontal conduit. The Bryant Electric Company, Bridgeport, Conn., has developed two devices for making inexpensive wall and ceiling fixtures. One of these has a porcelain base

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while the other has a brass base. The first of these is illustrated in *L* of Fig. 1. This company has also designed a cleat-base indicating porcelain snap switch for use in factories where open wiring is employed. An attachment plug which is armored by means of a brass ring to which is also fastened a clamp for holding the cord, has been developed by the Arrow Electric Company, Hartford, Conn. This metal piece is designed to prevent the composition cap from breaking and to prevent the cord from being pulled out of the binding screws.

Fig. 4—Machines and tools for repair and construction work.

At *A* is a commutator grinder which can be applied to practically any make of motor. A winder for armatures up to 5 hp. in size is shown at *B*. The taping machine at *C* is motor driven, the motor being part of the machine. A shop tool which can be used for turning and for milling and boring at all angles is illustrated at *D*. The device at *E* is employed to test all the coils in a small motor at once. Electrically heated solder pots (*F*) are becoming more popular. An arrester with solid electrolyte which requires no charging is shown at *K*. In using the battery filler pictured at *H* a small lamp lights when the cell is full. For taking a discharge test of a cell, the device shown at *I* needs only one hand of the battery man. At *J* is a welding outfit which can be transported easily to any section of a plant.

Repair-Shop Equipment and Tools for Repair and Construction

A motor-driven taping machine has been brought out by the Chapman Electrical Works, St. Louis, Mo. The taper is belted to a slow-speed motor on which is mounted a cone clutch which gives instantaneous and fine adjustment in speed correspond-



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ing to pressure on a treadle. This machine is illustrated in *C* of Fig. 4. A machine for turning a commutator without removing the armature from its bearings has been introduced by George Bender, New York City. This machine is made to take direct-current motors or generators or slip-ring alternating-current motors in sizes from 5 to 200-hp. The cutting tool is insulated from its holder. This device is shown in *A* of Fig. 4. A machine for winding the armatures of small motors has been developed by T. F. Rhoades, New York, N. Y., and is shown at *B* in Fig. 4. The guide feeding the wire onto the armature is moved by means of a cam shown near the wheel at the left of the machine. It is claimed that very fine wire and many turns can be wound with this machine. It is made for sizes up to 5 hp. A commutator-grinding tool designed for mounting on the brush holder stubs has been developed by the Martindale Electric Company, Cleveland, Ohio.

A brush connection which has been devised by the Boxill-Bruel Carbon Brush Company, Indianapolis, Ind., is shown in Fig. 7. This connection is made up as follows: Copper wire is pressed to a solid mass. The brushes are then milled to exact size and copper plated with a hole drilled for attaching the shunt. A tin washer is put on the front and a wing washer on the back to exactly fit the size of hole. This wing washer is threaded. A screw is then inserted through the front washer and through the brush and to the wing washer and screwed up tight. It is then immersed in a hot tin bath, which thoroughly saturates the pigtail and binds it securely to the copper plating on the brush and wing washer on the back.

When this brush is sawed through the connection it shows a solid mass where the pigtail connection is formed. The screw being solid to the copper pigtail prevents it from moving back and forth, and the wing washer fits in a slot in the brush which eliminates any turning movement. There are no high spots in the connection to become highly saturated. In the case where the pigtail is inserted in a hole in the top of the brush and a pin driven in on the side, there are one or two points which are higher than the rest of the material, which causes this contact to carry the current and in a short time jar away around the carbon or the metal by fusing and oxidizing so that the pigtail may be pulled out with little difficulty. In the construction described there is practically no voltage drop between the end of the shunt and the top of the brush.

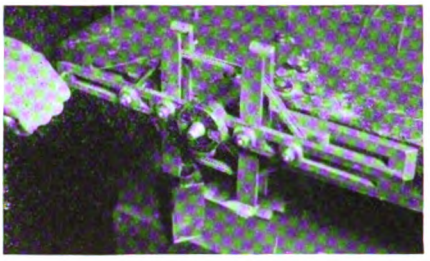


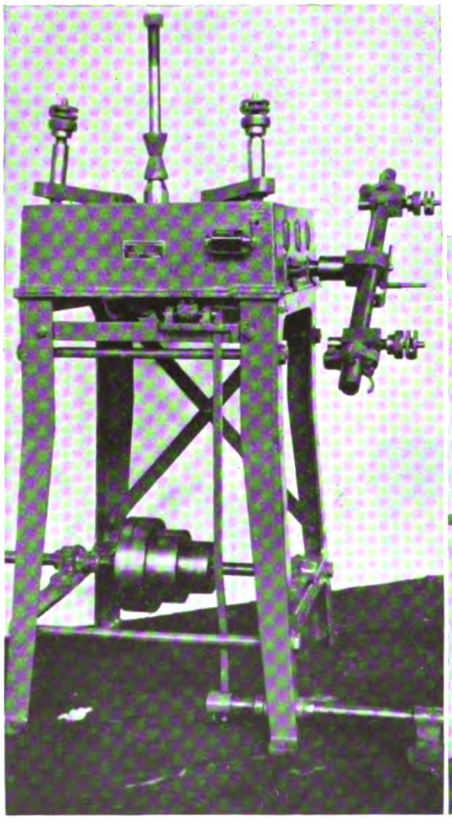
Fig. 5—An adjustable coil winding form made by Armature Winding Company, Charlotte, N. C.

A bias-woven varnished-cambric tape which has no seams has been put out by the Irvington Varnish & Insulator Company, Irvington, N. J. It can be continuously wound on without the necessity of stopping to cut out a seam.

Paul W. Koch Company, Chicago, Ill., maker of the "Jiffy" adjustable cutter, a hand tool for cutting circular holes of various diameters in metal and fiber plates, boxes, etc., has placed on the market a new tool known as the "Jiffy" drill press cutter. This cutter takes the place of the clumsy, old-fashioned, makeshift flycutter used in many shops. It can be used to cut holes in fiber sheets, metal plates, metal cabinets, and any kind of work of that nature which can be placed on a press. They are made in two sizes with cutting diameters from 1¼-in. to 3-in. and 1½-in. to 6-in. The knives are renewable and easily adjustable. This tool is to be used on machines at a speed of 100 r.p.m. or less on fiber material and 50 r.p.m. on metal. The standard knives cut metal 1/16 in. to 3/16 in. and special knives may be obtained which will cut thicknesses up to 1¼ in.

A machine for soldering all the joints of a commutator at one time has been developed by P. E. Chapman Electrical Works, St. Louis, Mo. This is a production machine arranged for one or a limited number of commutator sizes. A special design is made for soldering two commutators at once. The machine can also be employed for soldering rotors.

For testing the complete winding of a small armature at one time, an "armeter" has been built by P. E. Chapman Electrical Works, St. Louis, Mo. This instrument is intended for production work and one instrument will fit only one type of armature. A picture of this instrument is shown in *E* of Fig. 4. A complete



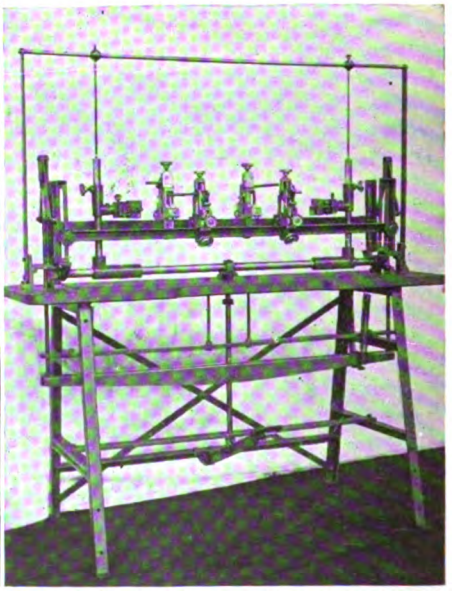


Fig. 6—Browning coil-winding machine and coil spreader.

This equipment is constructed to wind a variety of dimensions of coils that can be pulled into the required shape by the spreader shown at the right. It uses clamping arrangements which make it easy to adjust the heads of the winder and remove the coil when wound. The spreader is also designed for quick insertion and release of coils. This apparatus is made by the Mutual Foundry & Machine Company, Atlanta, Ga.

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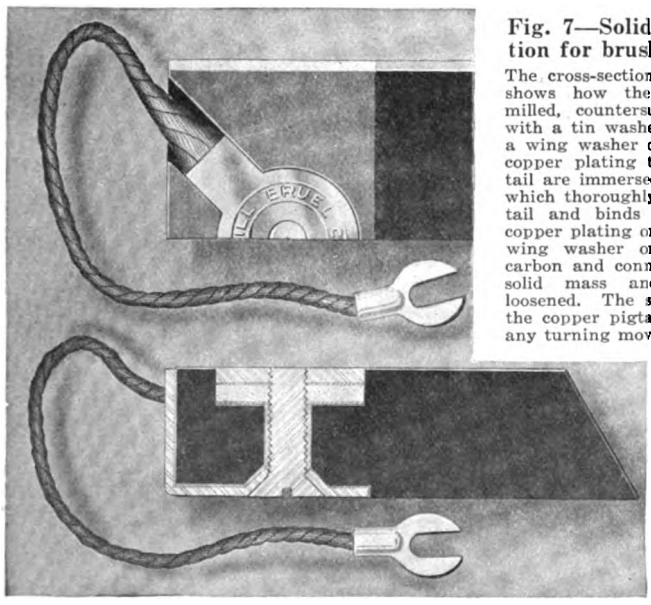


Fig. 7—Solid pigtail connection for brushes.

The cross-section in the illustration shows how the brush is drilled, milled, countersunk and assembled with a tin washer on the front and a wing washer on the back. After copper plating the brush and pigtail are immersed in a hot tin bath which thoroughly saturates the pigtail and binds it securely to the copper plating on the brush and the wing washer on the back.. The carbon and connections become one solid mass and cannot become loosened. The screw is soldered to the copper pigtail, thus eliminating any turning movement. In the construction described there is practically no voltage drop between the end of the shunt and the top of the brush Nor are there high spots to carry excessive current. This connection is made by Boxill-Bruel Carbon Brush Company, Indianapolis, Ind.

test bench for automotive repair shops, to be used for testing starting motors, generators, magnetos and distributors, has been built by Paul G. Niehoff & Company, Inc., Chicago, Ill. Tests can be made while the machine is in operation.

Among other items of equipment useful in a repair shop is a solder pot developed by the Westinghouse Electric & Manufacturing Company. These pots are made in 10, 30, 150 and 750-lb. sizes. The last two are equipped with automatic temperature control. An electrical heating furnace for heating soldering irons has been developed by the Op-al Electric & Manufacturing Company, Indianapolis, Ind. These furnaces are made in several sizes and can be attached to an ordinary lighting system.

A new type of soldering-iron heater has been developed by the Instantaneous Heater Company, San Francisco, Calif. The iron is heated by placing it across two carbon contacts fed from a 7-volt transformer. Current stops on removal of the iron.

An electrically heated soldering iron with a switch in the handle and a detachable cord has been put on the market by the Rhone Electric Company, Inc., Minneapolis, Minn.

Fig. 8—New electrically heated boilers and a brass-melting furnace.

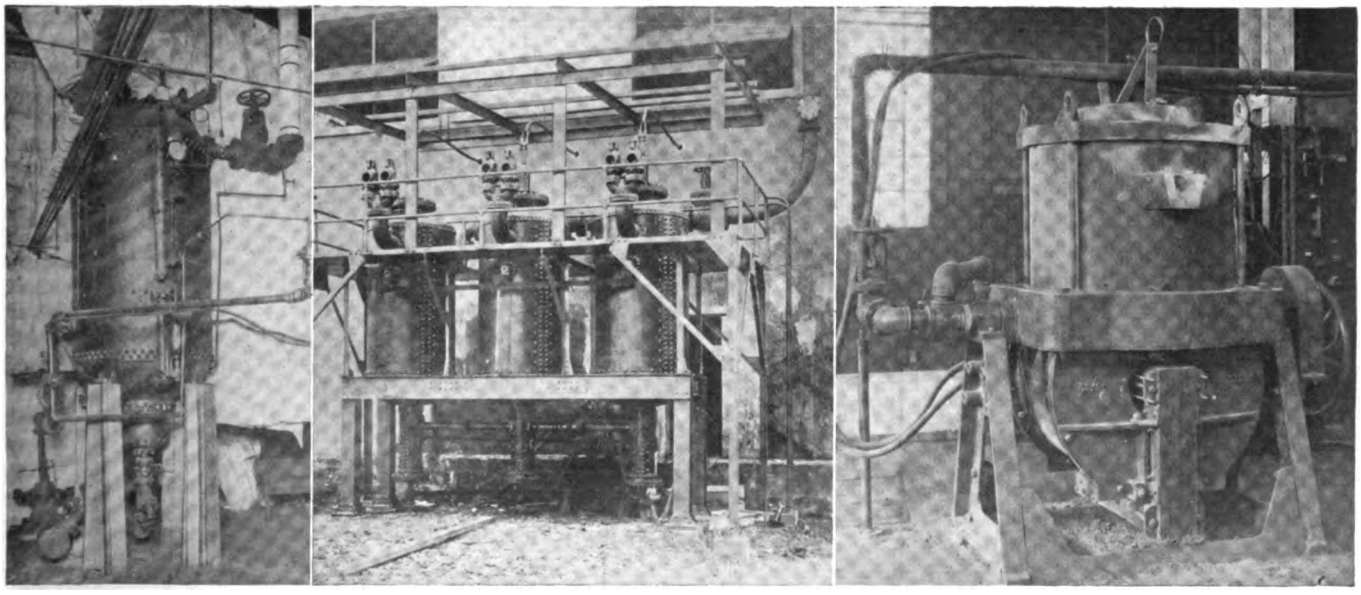
At the left is a smaller steam generator, while in the center is an 18,000-kw. electric boiler rated at 1,800 boiler horsepower, 12,000 volts, three-phase, 25 cycles. It evaporates 54,000 lb. of water per hour at 125 lb. pressure. The outside dimensions are 21 ft. by 10¼ ft. by 22 ft. It is installed at the Cliff Paper Company, Niagara Falls, N. Y. The 75-kw. repulsion-induction furnace shown at the right is said to have a consumption of 200-kw. hr. per ton of brass melted in continuous operation.

The iron is furnished in four sizes for 110 and 220 volts. A motor-driven gas blow torch has been made by the Armature Coil Equipment Company, Cleveland, Ohio. This torch is mounted on a stand which can be adjusted to any height. It is useful for removing insulation, soldering large commutators, burning out motor windings and other purposes.

Among the useful tools which have been developed for shop work is a three-in-one machine made by the Triplex Machine Tool Corporation, New York City. This machine is shown in *D* of Fig. 4. It may be used for turning, milling and boring. The motor and revolving shaft are mounted on a base which slides on an arm constructed in the shape of a quarter of a circle. This enables work to be done at any angle. A new design of pipe wrench shown in *G* of Fig. 4 has been brought out by the Greenfield Tap & Die Corporation, Greenfield, Mass. For pulling fish wires, T. J. Cope, Philadelphia, Pa., has brought out an instrument having two handles which are placed on each side of the wire while the pulling motion clamps the wire.

Equipment for the Battery Man

There are a few developments in which the man who handles batteries will be interested. A battery-charging outfit which will give 400 amp. under normal load and 500 amp. for a short time, has been placed on the market by the Hobart Brothers Company, Troy, Ohio. The generator is a 3-kw. machine with a commutator at both ends, each of which will deliver 200 amp. at 7½ volts. With the (*Continued on page* 101)



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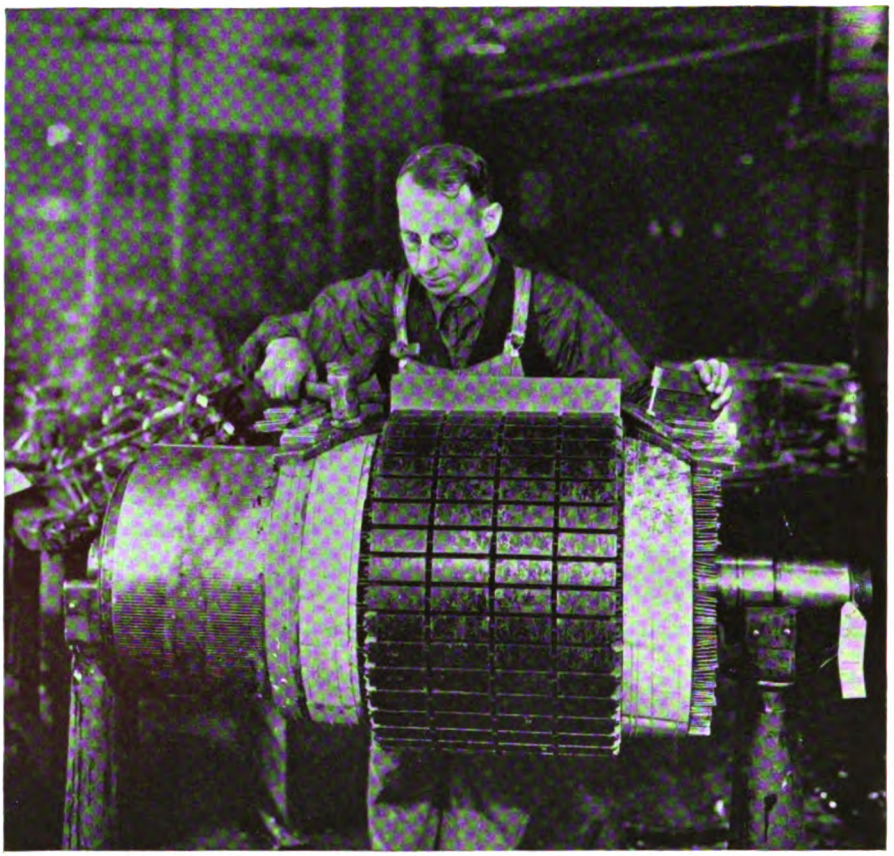
Winding and Connecting Data for Some

Old Direct Current Armatures

Including Those of Railway, Crane, Mining and Mill Type Motors and Some Generators

By A. C. ROE,

Shop Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company



An armature of this type and size sees hard service and its trips to the repair shop are frequent unless it is properly wound.

IN THIS ARTICLE Mr. Roe gives the coil pitch, commutator pitch and lead throw for some of the old types of direct-current motors and generators. These types are the S, SA, M, K, R, railway, crane, mining and mill types of Westinghouse make and a number of old style General Electric motors. The accompanying tables have been prepared from years of winding experience.

TIME may be saved when stripping an armature if the coil pitch, the commutator pitch and the lead throw is known in advance. In order to save this time the accompanying tables have been prepared for some old types of Westinghouse and General Electric motors. The Westinghouse motors included are types S, SA, M, K and R, and old types of railway, crane, mine and mill motors. A number of General Electric railway motors are also included. The data has been compiled from many rewinding jobs.

When stripping an armature the winder first finds out from the nameplate or by inspection what type the motor is. If the type is covered by the tables he need not stop to take the pitches and throw. He should, however, record the nameplate data and count the total number of slots and commutator bars. The coils can then be removed, saving one to use as a guide in making the new coils and to get the size of wire, number of turns, etc.

After the coils are made and ready to be put back on the armature, the tables should be consulted. The table for the type of the motor being rewound is first found and then the line referring to the particular winding is located. This is determined by the number of slots and commutator bars in the motor. For instance, if it is a type M motor with thirty-one slots and 93 bars, the motor winding data is found in the third line of the table referring to type M motors. Here we see that the coil pitch is 1 and 7, the pitch of the leads on the commutator is 1 and 48, and the throw of the bottom lead is 1 and 16.

It will be noted that some of the

Table I—Number of Slots and Bars in Different Frame Sizes of Types S and SA Westinghouse Motors

Frame No.	*No. Slots*	*No. Bars*
1	31-41	31-61-81-93
2	33-35-41-47-49	49-97-99-105-123-141
3	37-41-49-57	49-73-97-111-123-147-171
4	39-45-49-53-61	49-89-97-105-117-147-183
5	37-41-44-47-49-65	49-73-93-97-98-123-147-195
6	41-47-53-59	53-94-105-123-141-159-177
7	41-49-69	49-81-97-98-123-147-207
8	47-53-65-75	53-75-93-94-105-106-141-159-195
9	47-53-57-69	53-93-105-106-114-141-159-171-207
10	31-41-45-53-65	89-90-74-111-123-135-163-185-195-265
11	37-41-45-53-65	81-82-90-111-123-135-195-219-265
12	41-49-53-55-61-65-76	82-106-123-152-164-165-183-195-245
13	31-41-45-53-55-57-64-71-81.	61-82-110-123-128-135-165-171-213-143-265

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tables give the frame numbers. Where the frame number of a motor is known, this will help to determine which data to use. Sometimes this frame number is marked on the nameplate. There are marks on the commutator end of the shafts of Westinghouse types R, M, S, SA and railway motors. The marks might, for instance, be: No. 5-3T-97B-220V-30Hp., etc. In this case the "No. 5" would be the frame number.

If the motor is one that falls under the heading of Table V, it may be more difficult to tell exactly which data should be used for it. In this case it may be necessary to refer not only to the number of slots and bars in the motor, but also to its voltage and the size of wire and the number of turns in the coils. For instance, if we have a motor with 47 slots and 93 bars, there are several lines in Table V which might refer to this particular motor. However, if we know that the motor is rated at 500 volts, this limits the selection to four of the motors. Furthermore, if we know that the coils have four turns of No. 10 wire, while the motor is

Table II—Connecting Data for Four Different Types of Westinghouse Motors

No. Slots	No. Commutator Bars	Coil Pitch, A-B	Commutator Pitch, C-F	Throw of Bottom Lead, C-D	Refer to Drawing Numbers
		Types S and SA Motors			
31	31	1-8	1-17	1-6	1
31	61*	1-8	1-32	1-11	2 & 7
31	93	1-8	1-48	1-19	3
33	99	1-9	1-51	1-15	3
35	105	1-10	1-54	1-14	3
37	73*	1-10	1-38	1-11	2 & 7
37	74†	1-10	1-38	1-11	2 & 8
37	111	1-10	1-57	1-16	3
37	185	1-10	1-94	1-26	5
39	77*	1-10	1-40	1-12	2 & 7
39	117	1-10	1-58	1-17	3
41	81*	1-11	1-42	1-11	2 & 7
41	82†	1-11	1-42	1-11	2 & 8
41	123	1-11	1-63	1-18	3
41	163*	1-11	1-83	1-23	4 & 7
41	164†	1-11	1-83	1-23	4 & 8
44	98†	1-11	1-50	1-15	2 & 8
45	89*	1-11	1-46	1-15	2 & 7
45	90†	1-11	1-46	1-15	2 & 8
45	135	1-11	1-69	1-21	3
47	93*	1-12	1-48	1-15	2 & 7
47	94†	1-12	1-48	1-15	2 & 8
47	141	1-12	1-72	1-21	3
49	49	1-12	1-26	1-9	1
49	97*	1-12	1-50	1-16	2 & 7
49	98†	1-12	1-50	1-16	2 & 8
49	147	1-12	1-75	1-22	3
49	245	1-12	1-124	1-36	5
53	53	1-13	1-28	1-9	1
53	105*	1-13	1-54	1-16	2 & 7
53	106†	1-13	1-54	1-16	2 & 8
53	159	1-13	1-81	1-24	3
53	265	1-13	1-134	1-38	5
55	109*	1-13	1-56	1-17	2 & 7
55	165	1-13	1-84	1-25	3
57	171	1-14	1-87	1-25	3
59	177	1-15	1-90	1-25	3
61	183	1-15	1-93	1-27	3
64	128†	1-16	1-65	1-19	2 & 8
65	195	1-17	1-99	1-26	3
69	207	1-17	1-105	1-26	3
71	213	1-17	1-108	1-31	3
75	75	1-18	1-39	1-12	1
76	152†	1-18	1-77	1-23	2 & 8
81	243	1-20	1-123	1-34	3
		Type M Motors			
31	31	1-7	1-17	1-7	1
31	61*	1-7	1-32	1-11	2 & 7
31	93	1-7	1-48	1-16	3
41	41	1-9	1-22	1-8	1
41	81*	1-10	1-42	1-13	2 & 7
41	82†	1-10	1-42	1-13	2 & 8
47	47	1-11	1-25	1-9	1
47	93*	1-11	1-48	1-15	2 & 7
47	141	1-11	1-72	1-22	3
45	135	1-11	1-69	1-21	3
55	55	1-13	1-29	1-10	1
55	109*	1-13	1-56	1-17	2 & 7
59	59	1-14	1-31	1-10	1
59	117	1-14	1-60	1-18	3
61	61	1-15	1-32	1-11	1
61	121*	1-15	1-62	1-18	2 & 7
61	122†	1-15	1-62	1-18	2 & 8
61	183	1-15	1-93	1-27	3
65	129*	1-15	1-66	1-20	2 & 7
71	71	1-17	1-37	1-12	1
71	141*	1-17	1-72	1-21	2 & 7
		Type K Motors			
27	81	1-7	1-42	1-13	3
27	107*	1-7	1-55	1-17	4 & 7
29	87	1-8	1-45	1-13	3
29	115*	1-8	1-59	1-17	4 & 7
31	93	1-8	1-48	1-19	3
33	65*	1-9	1-34	1-11	2 & 7
33	99	1-9	1-51	1-15	3
33	131*	1-8	1-67	1-25	4 & 7
35	69*	1-9	1-36	1-11	2 & 7
37	73*	1-10	1-38	1-11	2 & 7
37	111	1-10	1-57	1-16	3
41	81*	1-10	1-42	1-11	2 & 7
41	123	1-10	1-63	1-18	3

*One dead coil. †One half-idle bar.

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rated at 500 volts, the motor is the one which has the coil pitch of 1 and 13, and the pitch of the leads on the commutator is 1 and 48. This is the data in the eleventh line of Table V.

The last column in the table tells which one of the drawings on this page should be consulted. In these drawings the coil pitch is shown as *A-C*. The commutator pitch is shown as *C-F* and throw of the bottom leads is *C-P*. The drawings show how the various coils are placed in the slots and connected to the commutator. Drawing No. 1 is employed for an armature having the same number of bars as slots, that is one coil to a cell. Drawing No. 2 is used where there is one less than twice as many bars as slots, and one dead coil. Drawing No. 3 shows three times as many bars as slots; drawing No. 4 four times as many,

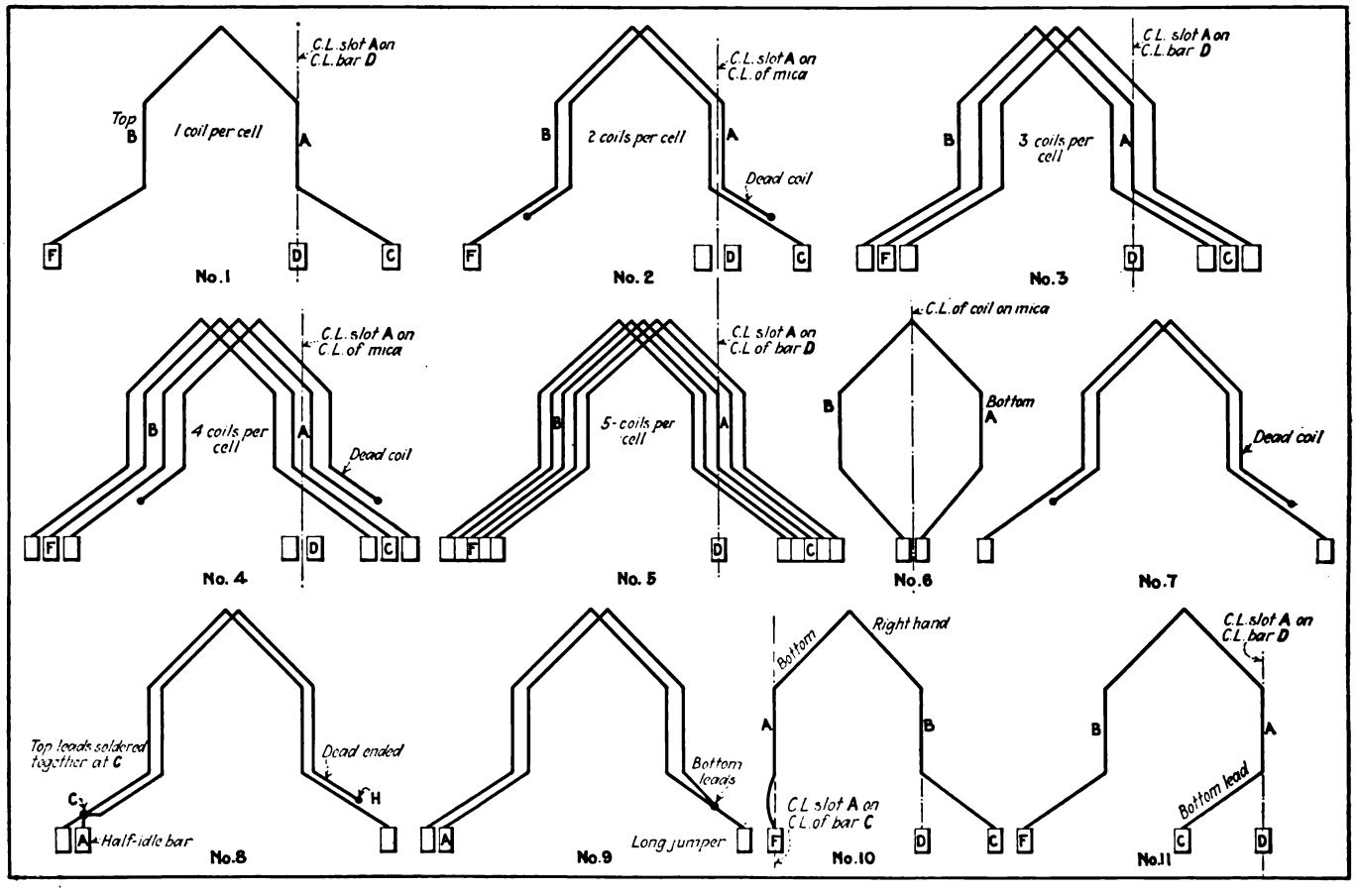
How lead throw is measured on various direct-current coils.

These are the drawings referred to in the tables accompanying this article. No. 6 alone refers to a lap winding and all the others to wave windings. The drawings show how the commutator bars line up with the slot holding the bottom of a coil. No. 7 shows a dead coil. No. 8 shows a bar which is "half-idle," that is, only one lead is connected to it. This is the top lead which is attached also to the adjacent coil at *C*. Sometimes the same result is accomplished as in No. 9. Here the bar *A* is again the half-idle bar. No. 11 is for a General Electric "1000" motor.

Table III—Connecting Data of Old Types of General Electric Motors

Frame Number	Number Slots	Number of Commutator Bars	Coil Pitch, A-B	Commutator Pitch, C-F	Throw of Lead, C-D	Refer to Drawing Numbers
800	105	105	1-27	1-53	1-27	9
1200	105	105	1-27	1-53	1-27	9
1000	93	93	1-24	1-47	1-13	10
50	105	105	1-27	1-53	1-27	9
51A	37	111	1-10	1-56	1-15	10
52	29	87	1-8	1-44	1-12	3
53	37	111	1-10	1-56	1-29	9
53	33	99	1-9	1-50	0	9
54	29	115*	1-8	1-58	1-15	4
55	47	141	1-12	1-71	1-14	3
57	37	111	1-10	1-56	1-15	3
57	33	99	1-9	1-50	1-13	3
58	33	99	1-9	1-50	1-13	3
60	37	111	1-10	1-56	1-15	3
61	41	123	1-11	1-62	1-16	3
65	55	165	1-14	1-83	1-19	3
66	39	195	1-10	1-98	1-17	5
67	37	111	1-10	1-56	1-15	3
70	37	111	1-10	1-56	1-16	3
73	39	117	1-10	1-59	1-12	3
74	39	117	1-10	1-59	1-16	3
80	37	111	1-10	1-56	1-16	3

*Has one dead coil.



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and No. 5 five times as many. All of the coils shown except No. 6 are for wave-wound armatures. No. 6 is a lap-wound coil. No. 7 shows how a dead coil is indicated. The first coil to the right of the first group is taken as the dead coil.

Drawing No. 8 shows how to connect a half-idle bar. It is connected to only one coil. Therefore it must be tied to an adjacent bar. The other end of the coil which connects to this half-idle bar is dead-ended. Such a half-idle bar might be employed for instance where there were 47 slots and 94 bars. In such a case there is one bar too many to give the proper winding. The bottom lead therefore is cut off as shown at *H*, of No. 8, and the end is taped. Then the top leads are soldered together as shown at *C*, and these leads are then brought out to their respective commutator bars. Bar *A* should then only have one lead, which is a top lead, attached to it. This makes this bar alive so that commutation will be satisfactory.

There is another way of doing this. Instead of soldering the top leads together as at *C*, the bottom lead is cut off and soldered to the adjacent bottom lead as shown in No. 9. The two top leads are then put in their respective commutator bars.

Drawing No. 10 shows a coil which has all its throw in its bottom lead. The top lead is connected straight out to a commutator bar. Drawing No. 11 shows the bottom lead bent in towards the center of the coils while the top lead has an extra long throw.

Table IV—Connecting Data for Westinghouse Types R and Railway Motors

Frame Number	Number Slots	Number of Commutator Bars	Coil Pitch, A-B	Commutator Pitch, C-F	Throw of Bottom Lead, C-D	Refer to Drawing Numbers
Type R Motors						
2†	12	36	1-6	1 & 2	.....	9
3†	18	54	1-9	1 & 2	.....	9
4†	20	40	1-10	1 & 2	.....	9
5	31	93	1-8	1-48	1-19	3
5	31	123*	1-8	1-63	1-19	4 & 7
6	35	105	1-9	1-54	1-16	3
6	35	139*	1-9	1-71	1-21	2 & 7
7	37	111	1-9	1-57	1-17	3
7	37	147*	1-9	1-75	1-23	4 & 7
7	41	81*	1-10	1-42	1-13	2 & 7
7	41	123	1-10	1-63	1-19	3
8	37	111	1-9	1-57	1-17	3
8	37	147*	1-9	1-75	1-23	4 & 7
8	41	81*	1-10	1-42	1-13	2 & 7
8	41	123	1-10	1-63	1-19	3
Railway Motors						
3	95	95	1-25	1-49	1-13	1
12A	47	93*	1-12	1-48	1-14	2 & 7
49	59	117*	1-14	1-60	1-18	2 & 7
68-68C	55	109*	1-14	1-56	1-16	2 & 7
56-81	39	117	1-10	1-60	1-17	3
38-38B	45	135	1-11	1-69	1-20	3
50L	55	165	1-13	1-84	1-25	3
101B	37	111	1-10	1-56	1-15	3
69	35	105	1-10	1-54	1-14	3
76	39	117	1-10	1-60	1-17	3
85	39	117	1-10	1-60	1-17	3
89	45	135	1-11	1-69	1-20	3
92A	41	123	1-10	1-62	1-18	3
93A	45	135	1-11	1-69	1-20	3
112	45	225	1-11	1-113	1-32	5

*Armature has one dead coil. †Hand-wound two-pole motors.

New Products Made In 1922

(*Continued from page* 97)

charger is furnished a switchboard which is equipped with two ammeters, voltmeter, rheostat and reversing switch. For filling storage Battery Company, Philadelphia, Pa., has developed the filler shown in *H* of Fig. 4. The end of the filler is inserted in the cell and the trigger is held down until a small electric bulb lights, as a signal that the cell is full.

A line of stills for making distilled water has been developed by the Barnstead Still & Sterilizer Corporation, Boston, Mass. The stills are made in capacities of from 1 to 3 gal. per hour and are heated by either gas or electricity. An instrument for making with one hand a high-rate discharge test on storage battery cells has been developed by the Service Station Supply Company, Detroit, Mich. This instrument is shown in *I* of Fig. 4. The same company is manufacturing an electrically heated knife operated on 6 volts, for removing sealing compound and also for resealing.

Among equipment which may be classed as signal apparatus is a new combined watchman and fire-alarm system devised by Edwards & Company, Inc., New York, N. Y. The box is so designed that the watchman on his rounds puts a key in each station which rings a bell and makes a record at the superintendent's office. To turn in the fire alarm, the box is operated in the usual way by breaking the glass and pulling a lever. Another interesting development by the same company is a single-stroke bell for alternating current. A new porcelain bell-ringing transformer has been developed by the Dongan Electric Company, Detroit, Mich.

An important development in the lighting field is a portable light meter for the measurement of foot-candles which is being manufactured by Keuffel & Esser Company for the Holophane Glass Company, New York City. This meter is said to give quick and accurate measurements. W. N. Matthews & Bro., St. Louis, Mo., have brought out a new portable lamp guard which shows especially rugged features.

The mill-type lamp which was

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developed in the latter part of 1919 is now produced in the following standard sizes: 25 and 50 watts for 115 volts, 50 watts for 230 volts and 275 volts. The 275-volt lamp is designed for mine lighting service.

The mill-type lamp in the 100-volt range is four or five times stronger than the regular Mazda B lamp in its ability to resist sudden shocks, etc. In the 200-volt range the lamp is about three times as strong as the regular Mazda B lamp.

Mill-type lamps have been successfully used in installations which are subject to severe shocks, and other installations where lamp strength is of greater importance than operating efficiency. They have also proved successful in a few rather unusual installations. An example of this is the use of mill-type lamps as headlights in mine locomotives, where a high voltage lamp is required. The mill-type lamps are not quite as efficient from an illuminating standpoint as are the regular Mazda B lamps, producing about 10 per cent less light than the corresponding regular lamp. This difference in illumination is due to the fact that some efficiency has been sacrificed to produce the strength feature.

Mill-type lamps are manufactured by the Westinghouse Lamp Company, the Edison and National Divisions of the General Electric Company. A few of the independent lamp companies also make these lamps.

Indicating and Testing Instruments

Among the important developments in instruments is one for measuring the insulation resistance of electrical machinery and cables. The resistance is read directly on a scale when a crank is turned at 80 r.p.m. The energy is furnished by a small 500-volt direct-current generator. A new line of direct-current instruments having a D'Arsonval movement has been completed by the Westinghouse Electric & Manufacturing Company. These are made in a variety of sizes and types for portable use and for mounting on switchboards, walls, tables and so on. The company states that an improved method of treating magnets has been developed which makes them practically free from changes. A corresponding line of alternating-current instruments is being placed on the market by the same company. A small ammeter, having no coils nor terminals, was also developed by this company. The current indications are obtained by passing the conductor through a loop of magnetic material at the back of the case.

The Westinghouse Electric & Manufacturing Company and the General Electric Company have developed for use at industrial plants small lightning arresters which contain no liquid electrolyte; the electrolyte is made of solid material.

A new type of ball bearing has been developed by Standard Steel

Table V—Data on Old Types of Railway, Crane, Mining and Mill-Type Westinghouse Motors

This table accompanies the article on page 98

Frame Number	Voltage	Number Slots	Number Commutator Bars	Coil Pitch, A-B	Commutator Pitch, C-F	Number Turns per Coil	Number Wires per Turn	Size and Kind of Wire
0	220	23	115	1-6	1-59	1	1	1/16 in. x 3/16 in. Strap
00	220	25	75	1-7	1-39	4	1	No. 10 DCC
000	220	29	87	1-8	1-45	6	1	No. 14 DCC
1	220	33	99	1-8	1-51	2	1	.0808 in. x .200 in. DCC Ribbon
2	220	31	155	1-8	1-79	1	1	.058 in. x .400 in. DCC Ribbon
3	220	45	135	1-11	1-69	1	1	3/32 in. x ½ in. Strap
4	220	41	123	1-11	1-63	1	1	3/32 in. x ⅝ in. Strap
4	220	45	180§	1-12	1-2	1	1	5/64 in. x ½ in. Strap
6	220	39	156§	1-11	1-2	1	1	7/64 in. x ⅝ in. Strap
RWY 3	500	95	95	1-25	1-49	4	1	No. 11 DCC
12	500	47	93*	1-13	1-48	4	1	No. 10 DCC
12	500	47	93*	1-13	1-48	5	1	No. 11 DCC
12A	500	47	93*	1-12	1-48	5	1	No. 10 DCC
12A	500	47	93*	1-11	1-48	4	1	No. 10 DCC
12A	250	47	93*	1-11	1-48	2	1	No. 10 DCC
38B	500	45	135	1-11	1-69	2	1	No. 9 DCC
38B	250	45	135	1-11	1-69	1	2	No. 9 DCC
39	220	47	94†	1-12	1-48	1	1	⅛ in. x ½ in. Strap
39	220	47	141	1-12	1-72	1	1	⅛ in. x ½ in. Strap
39	220	55	110†	1-13	1-56	1	1	⅛ in. x ½ in. Strap
49	500	59	117*	1-14	1-60	3	2	No. 9 DCC
50A	550	55	165	1-13	1-84	1	1	5/64 in. x ⅝ in. Strap
50E	500	55	165	1-13	1-84	1	1	5/64 in. x ⅝ in. Strap
50E	220	52	156§	1-13	1-2	1	1	5/64 in. x ¾ in. Strap
50F	250	55	165	1-13	1-84	1	1	5/64 in. x ⅝ in. Strap
50D	220	55	110†	1-13	1-56	1	1	⅛ in. x ⅝ in. Strap
50L	500	55	165	1-13	1-84	1	1	5/64 in. x ⅝ in. Strap
38B	220	45	135	1-11	1-69	1	1	1/16 in. x 7/16 in. Strap
54	220	47	93*	1-12	1-48	4	1	No. 9 DCC
56	500	39	117	1-10	1-60	2	3	No. 10 DCC
56A	220	39	117	1-10	1-60	1	1	1/16 in. x ⅝ in. Strap
57	500	39	117	1-10	1-60	3	2	No. 11 DCC
57	250	47	93*	1-12	1-48	2	2	No. 8 DCC
58	500	35	105	1-9	1-54	4	1	No. 9 DCC
58	220	35	105	1-9	1-54	2	2	No. 9 DCC
59	500	35	105	1-9	1-54	5	1	No. 10 DCC
59	220	39	117	1-9	1-60	2	3	No. 10 DCC
60	500	35	105	1-9	1-54	6	1	No. 12 DCC
60	220	35	69*	1-9	1-36	4	1	No. 9 DCC
61	500	39	117	1-10	1-60	7	1	No. 14 DCC
61	220	39	77*	1-10	1-40	5	1	No. 10 DCC
62	500	39	117	1-10	1-60	2	3	No. 10 DCC (same as No. 56)
64	500	35	105	1-9	1-54	10	1	No. 15 DCC
64	220	39	77*	1-10	1-40	6	1	No. 12 DCC

*Armature has one dead coil, Drawing No. 7. †Commutator has one half-idle bar, Drawing No. 8. ‡Split pitch. §Lap wound, Drawing No. 6.

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Bearings, Inc., Philadelphia, Pa. In this bearing the inner and outer races have two deep ball grooves. The groove curvatures correspond to the contour of the balls. A new type of key for pulleys and the like has been developed by Smith & Serrell, Newark, N. J. This key has two sharp corners cut at one end and is driven in so that it cuts the shaft and pulley away and thus insures a perfect fit.

Among the advances which have been made in electric heating is the electric steam generator. The generation of steam by passage of electrical current through it is coming into use in a number of applications in this country. Two examples of boilers for this purpose are shown at the left and the center of Fig. 8. Such boilers have proved successful under a number of different conditions. They may be employed to make waste power useful in industrial plants which have their own water power and generating equipment, where steam is needed during Sundays and holidays. When an industrial concern buys its power on a fixed annual charge under a certain maximum, it is sometimes impossible to use this maximum amount. During these times the electric boilers might be used to advantage. Where comparatively small amounts of steam are necessary at a considerable distance from the boiler house it will sometimes be found more profitable to transmit the electric power and generate the steam in an electrically heated boiler at the point of utilization. Another application of these boilers which is in use is the case where the central power station installs and maintains a boiler in an industrial plant and sells the energy on the basis of metered steam. Among the companies making such steam boilers are the General Electric Company, Schenectady, N. Y., and the Electric Furnace Construction Company, Philadelphia, Pa. The latter company has installed thirteen of these boilers during 1922, ranging in size from 3 boiler hp. to 1,800 boiler hp. and from 30 kw. to 18,000 kw. In one installation made by this company at the Laurentide Paper Company one man is operating two boilers with a capacity of 30,000 kw., equivalent to a total of 6,000 boiler hp. Slightly over 3,000 lb. of steam can be generated per kilowatt-hour and the actual operating efficiency usually runs around 98 per cent. The steam pressure in these boilers is dependent upon the customers' requirements, but the majority of the large boilers in various plants are operating at 120 to 150 lb. pressure.

The largest steel furnace yet installed is the 60-ton furnace of 12,000-kw. capacity for the new Ford plant at River Rouge. This furnace, which was made by the Electric Furnace Construction Company, is equipped with eight electrodes and the power can be fed either entirely through (*Continued on page* 118)

Table V Continued—Data on Old Types of Railway, Crane, Mining and Mill-Type Westinghouse Motors

This table accompanies the article on page 98

Frame Number	*Voltage*	*Number Slots*	*Number Commutator Bars*	*Coil Pitch, A-B*	*Commutator Pitch, C-F*	*Number Turns per Coil*	*Number Wires per Turn*	*Size and Kind of Wire*
65	500	39	117	1-10	1-60	6	1	No. 11 DCC
65	220	35	105	1-9	1-54	3	2	No. 10 DCC
66	500	39	117	1-10	1-60	9	1	No. 14 DCC
66	220	47	93*	1-11	1-48	5	1	No. 10 DCC
67	500	37	111	1-9	1-57	7	1	No. 13 DCC
67	220	37	73*	1-9	1-38	5	1	No. 10 DCC
68	550	55	109*	1-14	1-56	3	2	No. 12 DCC
69	500	35	105	1-10	1-54	4	1	No. 10 DCC
73	500	39	117	1-10	1-60	9	1	No. 15 DCC
73	220	35	105	1-9	1-54	5	1	No. 11 DCC
75	500	35	105	1-9	1-54	5	1	No. 10 DCC
75	220	39	117	1-10	1-60	2	3	No. 10 DCC
76	500	39	117	1-10	1-60	2	3	No. 9 DCC
76	220	31	93	1-9	1-48	1	1	1/10 in. x ⅝ in. Strap
76A	220	39	117	1-10	1-60	1	1	5/64 in. x ⅝ in. Strap
79	500	35	105	1-9	1-54	4	2	No. 12 DCC
83	600	49	196†	1-12	1-99	1	1	3/64 in. x ⅝ in. Strap
85	500	39	117	1-10	1-60	2	2	No. 9 DCC
86	570	53	159	1-13	1-81	1	1	⅛ in. x 7/16 in. Strap
89	500	45	135	1-11	1-69	2	3	No. 10 DCC
92A	550	41	123	1-10	1-62	3	1	No. 10 DCC
92A	220	45	135	1-11	1-68	1	1	3/32 in. x ½ in. Strap
93A2	550	45	135	1-11	1-69	2	2	No. 10 DCC
95	500	37	111	1-10	1-57	3	1	No. 9 DCC
96	220	52	156§	1-13	1-2	1	1	5/64 in. x ¾ in. Strap
101B	500	37	111	1-10	1-56	3	1	No. 9 DCC
101D2	500	45	135	1-11	1-69	2	2	No. 11 DCC
102A	500	39	155*	1-10	1-79	2	2	No. 6 DCC
102A	220	27	135	1-7	1-69	1	1	5/64 in. x ⅝ in. Strap
101K	500	25	125	1-7	1-63	4	1	No. 10 DCC
115	250	47	93*	1-12	1-48	2	2	No. 8 DCC
109	500	55	165	1-13	1-84	1	1	5/64 in. x ⅝ in. Strap
112	550	45	225	1-11	1-113	1	1	3/64 in. x ½ in. Strap
113	550	31	155	1-8-9‡	1-78	1	1	⅛ in. x ½ in. Strap
119	500	37	185	1-10	1-94	1	1	1/16 in. x ⅝ in. Strap
121A	500	41	205	1-11	1-104	1	1	3/64 in. x ⅝ in. Strap
122	500	47	188†	1-8	1-64	2	2	No. 8 DCC
122	220	43	172†	1-8	1-58	1	1	3/64 in. x ⅝ in. Strap
131	500	39	117	1-10	1-60	5	1	No. 11 DCC
131	220	35	69*	1-9	1-36	4	1	No. 7 DCC
155	220	35	69*	1-9	1-36	4	1	No. 7 DCC
158	250	40	160†	1-8	1-54	1	1	1/16 in. x ⅝ in. Strap
230	500	41	123	1-10	1-63	2	2	No. 9 DCC

*Armature has one dead coil, Drawing No. 7. †Commutator has one half-idle bar, Drawing No. 8. ‡Split pitch. §Lap wound, Drawing No. 6.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
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Chicago, February, 1923

Why Not Make the Hard Job Easy?

A MAN who has had long and varied experience in maintenance work was once asked how he overcame any tendency on the part of his men to neglect inspection of inaccessible motors and equipment, and in general to slight the hard jobs. "There aren't any hard jobs around here," he replied. "I make it my business to see that the men are given the proper equipment and facilities for making every job an easy one."

His statement expresses a truth that is often overlooked. Usually the main difference between an easy job and a hard one lies in the availability or absence of the proper facilities for doing the work.

It is rather strange that while every precaution is taken to protect the worker at bench or machine from injury and to help him in all practicable ways, in many cases little or no attempt is made to lighten or make less hazardous the work of the inspector or maintenance man. Cleaning lamps and inspecting or repairing equipment which is mounted overhead or in other hard-to-reach places, is hard work in that a good deal of physical exertion is required, and in addition there is always present more or less risk of injury from falls or other mishaps.

Permanent ladders or even rungs attached to building columns, walls or elsewhere, will make climbing up and down both easier and safer. Or an ordinary ladder may be hung in some convenient place and thus relieve the inspector of the necessity of carrying it with him. Likewise, small platforms with guard rails will provide a safe place to stand while inspection or repair work is being done on equipment mounted overhead. But better still is the plan of considering maintenance when the installation is made and arrange things as accessible and get-at-able for maintenance men as possible.

Shirking hard or dangerous jobs is not necessarily an indication of laziness; it may be merely self-preservation. The most effective remedy for it is to make the so-called hard jobs easy by eliminating so far as possible the dangerous or disagreeable features.

Where Do Dividends Come From?

A CAREFUL study of the source of profits usually shows that they can be traced in many cases to reclaimed wastes. "Everyday operation and production pays the expenses but the profits come from the reduced junk pile," is the way one large manufacturer expresses it. But more than wasted material goes into the junk pile; it contains in addition, hours of labor of men and machines as well as the time and attention of the yard and shop gangs engaged in the miscellaneous handlings through which it passes.

For years most of the managerial attention has been directed toward increasing the productive value of men and machines and ignoring the tremendous wastes of large gangs of men engaged in miscellaneous handling routine. That it is profitable to make these studies and changes is well shown by a recapitulation of some of the examples already given in the "Handling Materials" section of the INDUSTRIAL ENGINEER. For example, on page 64 of the January, 1923, issue, the story of a $21,000 a year saving is told. The necessary additional equipment, a special roll paper storage battery truck, which cost only a few thousand dollars, has repaid its initial cost several times over. In another instance (page 552, November, 1922) a traveling crane and magnet over a scrap iron yard saved $1,000 a year by eliminating the cost and maintenance of wheelbarrows alone. In addition, cars could be loaded better, more quickly and at less expense than by hand labor.

Other instances of savings recorded are: Doubling storage capacity by piling higher and at less expense through doing it mechanically; doubling the productive capacity by a conveyor installation; cutting in half the cost of handling coal to and from storage, and also of charging and discharging malleable furnaces. Many more illustrations are given in this department; in some cases, however, the new method did the former task so quickly that it took on additional duties and so made the actual savings difficult to estimate.

In all of these instances the waste of time and money had been going on for years. In contrast the savings will continue indefinitely or until superseded by other methods more economical. Does the elimination of these wastes pay dividends? The saving of $21,000 a year will pay 6 per cent on $350,000. Companies that are prosperous pay dividends and usually are more liberal with wages and salaries, too.

Do You "Shop" for a Spool of Thread?

NO doubt those who read what follows have laughed over the story of the frugal housewife who paid carfare from her home in a distant part of a city to a large drygoods store and return, to buy a spool of thread because it was a cent cheaper than at the little shop just around the corner. But it's not such a joke as it may seem for many of us might question our own personal practice in applying such economy to our purchasing methods.

In a recent study of some purchasing methods of various companies, a circumstance involving a similar expenditure with little economy was discovered. The purchasing department of a concern had the hard and

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fast rule of making inquiries and receiving quotations on every article purchased. In this case, the purchasing department actually sent out inquiries to six different concerns for quotations on one cast-iron collar for a lineshaft, the total value of which would be about 30 cents. The cost of the six letters, which are generally figured at about 25 cents apiece, the time spent in receiving and tabulating the replies, and the time which must be given to interviewing salesmen who, with a lead of this sort, would inevitably call, would total many times the original cost of the collar. This would also take time and delay the work of the maintenance department in its installation. This is not an exaggerated condition but actually happened and it is unfortunate, but true, that this or a closely related practice is not hard to find in many organizations.

Some concerns have eliminated much of this needless waste through dealers who can supply from stock any of the miscellaneous pulleys, belts, bolts, or other mill supplies which may be necessary. If in a hurry orders are issued over the telephone and confirmed later or a messenger is sent directly to the supply house with an order and waits till it is filled. "Shopping" frequently saves money, but usually its main function is to indicate the best place to buy.

Learning a Trade vs. Holding a Job

WE recently received a letter from the chief electrician of a large paper mill in which the following comment was made: "Another point that I wish to bring out is the attitude of a great many men today, especially young fellows starting in, that they are holding a job and not learning a trade, but believe their promotion should come because they are in line for the next job."

Many men who graduate from an engineering school sort of back into practical work. That is to say, they have a little better opinion of their ability than anyone else and fasten their eyes on a position while their back is turned on their opportunity and they must either be pushed into it or stumble into it. Most of the men with degrees from engineering schools who have gone ahead fastest in practical work are those who have shown a willingness to start at the bottom and dig their way up with their eyes, their hands and their ingenuity. They have not assumed a know-it-all attitude and have used their college training simply as a tool in the analysis of the work they have to do. They have studied the methods of older practical men and learned a lot from them, they have analyzed their work from the standpoint of its effectiveness and costs, and they have never refused to undertake a thing that might soil their hands or hurt their pride. They have dug-in and in many cases where promotion has come by reason of this attitude and the results shown, they have given up the old work for the new with some reluctance because they were in love with it. But in the new work they have dug in again and so have gone on and up.

This is not only true of young college men for many men who never sat in the halls of higher learning have followed this kind of procedure and by self study and initiative have mounted to places that others with college training have failed to secure. Any man who makes up his mind to learn one or more trades and shows an ambition to get ahead will never have to wait for dead men's shoes. Men in industrial works are looking for just such young men and opportunities for promotion are frequently closer than they often know when they show the ability to analyze themselves as well as the work they are given to do.

Light Is Needed Two Hours Every Day

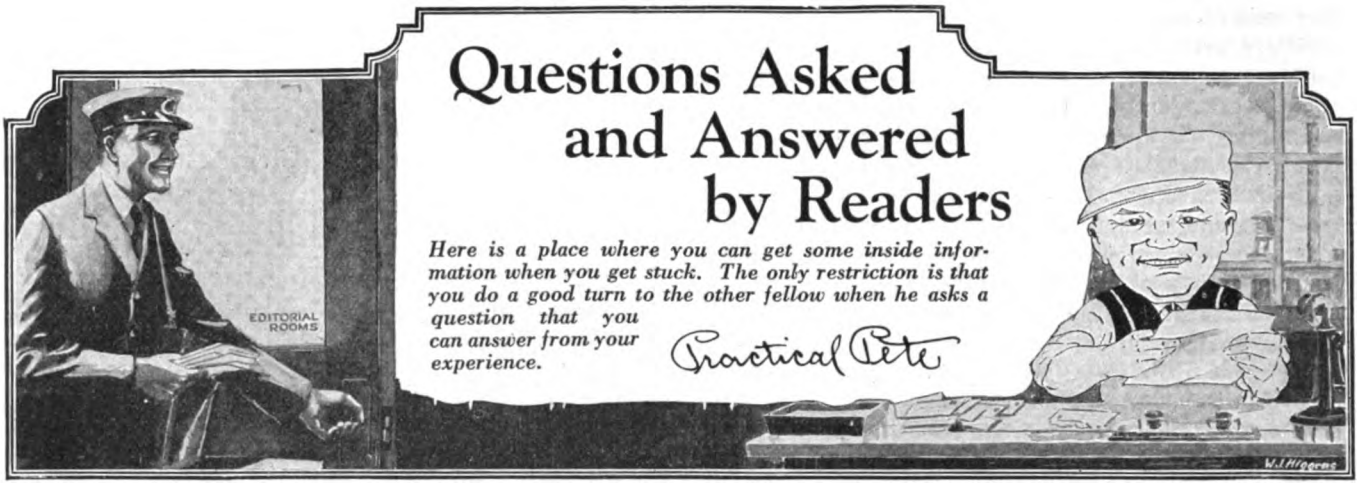
NOW that the working day begins to have more hours of daylight, the tendency is to postpone needed improvements in illumination to which the darker days have called attention. Even in summertime in buildings where good use is made of daylight illumination, there is in particular departments at times a dependence upon artificial illumination. When it is not provided, the speed of production automatically slows down with the result that the actual hours of maximum production are reduced.

If, therefore, the past few months have shown a need for better artificial illumination, this need can be supplied with profit before the longer use of lamps each day comes up next fall. And there is a need for better lighting in many plants. This was shown through details of a report presented recently by W. H. Rademacher of the Edison Lamp Works before the Illuminating Engineering Society. In that report Mr. Rademacher made the following comment:

"Manufacturing buildings are invariably constructed so that the maximum amount of daylight illumination is insured, it apparently being realized that daylight illumination of a high order is well worth having. It seems almost paradoxical then that a good many of these plants which are so well fortified from the daylight manufacturing standpoint have artificial lighting systems which may be considered far from adequate. Artificial light by many still seems to be considered a necessary evil and lighting systems under these conditions are merely the application of a lamp bulb, as such, rather than the procurement of real illumination. * * * * When we remember that in the so-called daylight industries there are approximately 300 working days per year in which there is an average of 2 hours per day during which artificial light is required, we can quite fully appreciate that really good artificial light is essential and has a bearing on the plant's successful operation."

In making a check on lighting conditions it is recommended in the above-mentioned report that attention should be given to the following points: (a) General character of building; (b) analysis of the processes of manufacturing; (c) present lighting practice; (d) recommended practice as to intensity, type of equipment and method of lighting; (e) special or peculiar lighting requirements. Whether or not the lighting of a plant is adequate, an inspection covering these points by the maintenance department as a regular procedure a couple of times a year will provide useful information when changes or additions in plant departments are being made and at the same time serve as effective checks on the illumination requirements to best suit production conditions. When a new lighting system is installed it does not follow that it will be adequate for all time, especially when changes in operating processes are frequent and the character of product worked on changes from time to time. Definite checks should be made on lighting to insure that all the energy converted into light is used and not wasted and for the same reasons that checks are made on the effective use of any other raw material required in the product.

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Who Can Answer These?

Origin of the Name "Bug"—Can you explain in the columns of INDUSTRIAL ENGINEER when and where the expression "the bug in the circuit" arose? I presume it comes down from the telegraph days. I would like to hear from some of the old-timers on this point.
Raleigh, N. C. W. H. B.

* * * *

Size of Pulley on a Motor—The writer would like to request readers of INDUSTRIAL ENGINEER to indicate what is considered good practice in the dimensions of pulleys for d. c. and a. c. motors. For instance, is it good practice to use a pulley larger than the diameter of the armature? If not, why?
Orange, N. J. R. H. S.

* * * *

Changing Speed of Single-Phase Motor—I have recently had trouble with a single-phase, 3-hp., 1200 r.p.m. motor which was marked Variable Speed on the nameplate. This motor has four brushes, two on compensating winding and two on the main winding, but seems to be a six-pole design. I would like to know how this motor can be changed to get a variation in speed.
Kings Park, N. Y. N. J. W.

* * * *

Trouble with Motor Generator—We have a 175-kva. motor generator set which is giving us trouble. The motor is a synchronous type operated at 2,200 volts. The generator is direct connected and produces 250 volts, d. c. The trouble we are having is with the a. c. motor. The stator and rotor of this machine have been rewound six times during the last year and a half. It carries a load of about two-thirds capacity but must and does handle 50 per cent overload for about two minutes over fifteen-minute periods. The generator is handling a load of mine locomotives and the overload occurs when the locomotives are taking the crest of a grade. However, the temperature rise of the machine at the end of a day's run is not higher than allowed by the manufacturer. The machine seems to be O. K. until it lets go, there being no evidence of slowing down. So far as we can ascertain, it seems as though the pole face winding gives way and this rips up both stator and rotor. The d. c. generator will not over-compound, even with all the shunt field cut out. I would like to see some explanation of the cause and remedy for this trouble.
Vincennes, Ind. T. J.

* * * *

Changing D. C. Motor to a Generator—We have a d. c. Holtzer-Cabot motor with the nameplate rating and armature construction as follows: 120 volts, 2.7 amp., ¼ hp., 675 r.p.m., 2-pole, shunt wound. The armature has 18 slots and 36 coils. The coil span is 1 to 9. One coil has 26 turns of No. 33 d.c.c wire. The armature is lap wound. The field winding has 2,100 turns of No. 25 s.c.c wire. There are two poles. We desire to use this motor as a direct-current generator at a speed of 1,700 r.p.m, generating 10 volts. Can the rating of the generator be made approximately the same as the motor and what will be the amperage when generating 10 volts? If this change is possible, please give full details with the diagram for rewinding the armature and the fields.
Vallejo, Cal. L. Z.

* * * *

Correcting Power Factor—Will some reader of INDUSTRIAL ENGINEER give me information on types of meters and connections for use on a 3-phase, 3-wire, 60-cycle, 240-volt circuit to indicate the power factor of the motor load? At present we are operating two M. G. sets with synchronous motors rated at 225 kva. each. In case these motors are operated at a power factor of 80 per cent, what will be the effect on the power factor of the mill line? Under conditions that cannot be avoided, most of our equipment is over-motored and the power factor is low. To what extent have synchronous motors been used as synchronous condensers, and also to what extent have static condensers been used for conditions such as named?

I would also like to get some information on the use of magnetic clutches and their effectiveness when machines must be started and stopped several times per hour.
Ambridge, Pa. N. H. C.

Answers Received To Questions Asked

Crane Collector Wires—On a five-ton alternating-current crane, having a bridge or cross travel of about 50 feet, we have experienced considerable trouble with the collector wires sparking at the contacts. Both types of collectors have been tried out; namely, shoes and wheels, and we have been forced to use flexible cables to do away with standard collecting devices.

Can readers tell us what the trouble is and how they overcome such difficulties in practice, for we do not feel it should be necessary to resort to the method we have adopted?
New York, N. Y. M. K.

Sparking at crane collector wires may be caused in several ways. On one occasion the writer had considerable trouble on a 550-volt, a. c. crane in a steel foundry. The sparking was always worse near the ends of the wires and was stopped by raising the arm carrying the collector wheels. In the center the weight of the wires caused them to sag a little so that they made pretty fair contact with the wheels under them, but near each end where the wires were supported they were barely touching the wheels.

The arm was reset so that the bottom of the groove on the top side of the wheels was about ⅛ in. above a taut line held underneath and touching the collector wires at both ends immediately next to their points of support. While this gave a good contact, yet it was not tight enough to cause the wheels to bind against the wires near the ends of their travel.

Another fruitful cause of sparking is dirt on the wires. This as well as burned and dirty contacts at the controller will generally cause the motors to run single-phase and

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where the designer has not been very liberal as to the size of the collector wires or of the collector wheels or shoes, this will generally cause sparking. Dirt on the wires should be looked for especially after the crane has been under repairs, such as changing bearings, gears, etc., when a lot of dirty grease and oil is often dumped over the sides without much regard for the collector wires.

Again, when using wheels, sparking may be caused by the wheels not turning on their spindles. This causes the wires to cut a groove in the top of the wheels. No trouble will be noticed as long as the wire stays in this groove, but if a sudden jar should shake the wire out of its groove, it might not get down again to the bottom and will make very little contact, thus causing sparking.

A much lower voltage than the motors are designed for will also cause sparking through excessive current. J. H. GALLANT.

Belleville, Ont., Canada.

* * * *

Making Equipotential Connections—In the book by D. H. Braymer on Armature Winding and Motor Repair, page 22, the statement is made, "With lap windings, one ring for every 6 to 12 segments is common practice, but this is scarcely feasible when the number of pairs of field magnet poles is greater than the number of sections of armature winding in parallel, for here the potential pitch may be fairly large and the number of rings becomes prohibitive." In the case of a large generator having 200 or more segments we would have a very large number of rings and they would form a bulky mass. I would like to see an explanation of how to make these equipotential connections for a particular case, showing how the taps are made.

Brooklyn, N. Y. I. T.

In the December issue I noticed I. T.'s question regarding equipotential connections which is quite fully answered by A. C. Roe. I would like to call attention, however, to the following. I. T. quotes a statement from D. H. Braymer's book on Armature Winding and Motor Repair which refers to equipotential connections on lap wound armatures and then inquires how this applies to a machine in which the number of pole pairs is greater than the number of armature winding sections in parallel. If that means that the armature is wave wound, then the equipotential connections are not required because in such windings each circuit is equally affected by all poles, and therefore the generated e.m.f.'s must be equal in each armature branch thus eliminating the necessity for using equipotential connections. HENRY H. METZENHEIM.

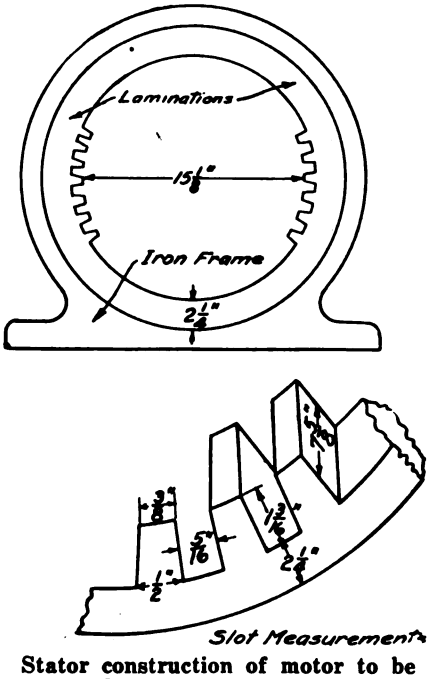
Newark, N.J.

* * * *

Figuring Horsepower of Motor From Winding Data—I have a motor with the nameplate taken off so that the rating is not known. Will someone please tell how to figure the horsepower and the ampere rating from the sketch and data which follows?

This motor has been operating on a 440-volt, 3-phase, 60-cycle circuit. The old winding had coils of 7 turns of No. 16 B & S gage wire, 3 wires in parallel. There are 72 slots with 18 pole-phase groups or 6 poles per phase, with a total of 72 coils. The coil pitch is 1 to 11 and the connection is a one-circuit star. The rotor of this motor is bar-wound and not of the slip-ring type.

Wisconsin Rapids, Wis. I. D. K.



Stator construction of motor to be rewound.

With regard to I. D. K.'s question regarding how to figure the horsepower of a motor from the winding data, first check the core to determine the allowable horsepower rating as per A. M. Dudley's book on "Connecting Motors" and the Standard Electrical Engineer's Handbook.

According to the figures given, the core is good for 45 to 50 hp. at 12,000 r.p.m. but a 40-hp., 3-phase, 440-volt motor will pull approximately 55 amp. at full load, while a 50-hp. motor will pull 64 amp.

Three No. 16 wires have a total area of 3×2582 equals 7746 circ. mils. Then with a series-star connection the current per phase is equal to the line current. The circ. mils per amp. for a 40-hp. rating would be 7746÷55 equals 140, approximately, which is too low a value for this size motor. Figuring 325 circ. mils per amp., the winding will be good for approximately 25 amp., or 20 to 25 hp.

Detroit, Mich. A. C. ROE.

* * * *

Regarding I. D. K.'s question in the November issue of INDUSTRIAL ENGINEER, I would advise as follows:

Professor Hobart's formula (H.P. $=K\times D^2L\times R.P.M.\times L$ where K in this case is .00028) gives, approximately, 44 hp.

Professor Gray's formula (H.P.$=D^2L\times 2.35\times B\times$ eff. $\times$ p.f. $\times$ R.P.M. $\times 10^{-12}$) gives, for a suitable gap density, an efficiency of 0.88 and p.f. 0.85, about 41 hp.

However, with the winding connected one-circuit-star, it is evident that I. D. K. is not getting even 50 per cent of the possible output of the machine, and should reconnect it two-circuit-star. By checking this winding electrically with the two-circuit-star connection and suitable values of circular mils per amp. and ampere conductors per inch, I find that the output is in the neighborhood of 40 hp. which checks very closely with the mechanical calculations mentioned. K. C. GRAHAM.

Buzzell Electric Works,
San Francisco, Cal.

* * * *

Small Condenser for 110-Volt A. C. Circuit.—I want to make some experiments with condensers on a. c. circuits of 110 volts, the capacity of the condensers to be approximately one microfarad. 1. Where can I obtain the necessary sheets of tin foil? 2. What should I use for the dielectric? 3. Where can I obtain same? 4. What thickness should the dielectric be for 110 volts a. c.? I have never seen any of this material advertised, consequently this request to you.

Logansport, Ind. L. E. G.

In answer to L. E. G. who asks in the November issue of INDUSTRIAL ENGINEER for data on small condensers, I would refer him to the Stromberg-Carlson Telephone Manufacturing Co. of Rochester, N. Y. This company manufactures a line of small, tin-foil condensers, neatly enclosed in insulated sheet metal cases. The condensers range in capacity from 0.4 to 5 m.f., and are tested with a breakdown voltage of 350 volts. They are quite reason-

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ably priced and, I believe, ought to be satisfactory for this reader's work. We have used them on 115 volts.

Electrical Engineer, J. M. WALSH.
Gurney Elevator Company,
Honesdale, Pa.

* * * *

Regarding the question by L. E. G. in the November issue, (1) the tinfoil can be obtained from any supply house handling radio supplies; (2) paraffined paper is suitable for the dielectric in condensers for use on 110-volt circuits; (3) the paper can be purchased from the same dealer supplying the foil; (4) the thickness of dielectric necessary depends upon the maximum voltage impressed upon it but 0.015 inch paper is ample. For calculating condensers of a particular capacity, the following formula can be used: $C=(K\times A\times 2248)\div(T\times 10^{16})$, where C equals capacity in mfds.; K equals a dielectric constant (2 for paraffined paper); A equals area of conducting surface and T equals thickness of dielectric in inches.

Detroit, Mich. J. B. RAKOSKE.

* * * *

Changing Two-Phase Starter for Three-Phase Operation. — In the August issue A. C. Roe gave a sketch illustrating how a two-phase starter can be connected for three-phase operation. May I ask Mr. Roe if this is not a wiring sketch of a Westinghouse compensator? Will changing of external connections only, hold good on other makes of compensators? M. A. D.
Intercourse, Pa.

While the sketch in question refers to a Westinghouse three-phase auto-starter or compensator used to start an induction motor, it can be changed to operate on two-phase, three or four wire service. If the starter has three coils, all three can be used, or the middle coil can be cut out of circuit.

The principle used is an auto-transformer connected to reduce the voltage applied to the motor terminals. On three-phase starters two coils are used in later types. That is, one in each outside leg. Then if it is desired to use the starter for a two-phase, four-wire circuit, without adding extra contacts, four wires can be brought to the compensator.

As the copper in the coils will not work up to the maximum on two-phase, the starter can be used for a larger two-phase motor; that is, a 20-hp., three-phase starter could be used on a 25-hp., two-phase motor.

Detroit, Mich. A. C. ROE.

R L M Standard Dome Reflectors.—We would like to see published in INDUSTRIAL ENGINEER an explanation of what is meant by the term "R L M Standard Dome Reflector" and how this name originated.

Chicago, Ill. F. E. G.

The question on page 592 of the December issue of INDUSTRIAL ENGINEER has been called to our attention and in answer thereto, we would submit the following: Several years ago, the illuminating engineer of one of the lamp manufacturers, feeling dissatisfied with the types of industrial reflectors being sold for use with Mazda C lamps, called a conference of all the illuminating engineers of the Mazda lamp manufacturers. As a result of this activity, the design now known as RLM (Reflector and Lamp Manufacturers') Standard Dome Reflector was unanimously agreed upon as the best all-around reflector to make available for the vast majority of industrial lighting problems.

A set of rather rigid specifications was drawn up to insure quality, and the name "RLM Standard Dome" selected as a means of designating the reflectors. In order to assure adherence to the specifications, arrangements were made with the Electrical Testing Laboratories, New York City, to conduct periodic inspection of the product of each manufacturer. Further, to insure a disinterested administration of the plan, the Electrical Testing Laboratories have been requested to handle the relations with the various reflector manufacturers. In accordance with this arrangement, the

These are the details covered by specifications for porcelain enamel steel reflectors, known as the RLM Standard Dome.

REFLECTOR AND LAMP MANUFACTURERS' STANDARD SPECIFICATIONS

For Porcelain Enameled Steel Reflectors

The Reflector and Lamp Manufacturers' Standard (abbreviated RLM Standard) specifications for dome reflectors, are as follows:

DOME REFLECTORS

Art. 1. Material and Workmanship—The material shall be porcelain-enameled steel The quality and weight of material, and the workmanship, shall be such as to insure a good serviceable product, which will withstand ordinary handling without losing shape and without cracking of enamel

Art. 2. Angle of Cut-Off—In every case the reflector shall present a continuous surface so proportioned that in ordinary use with a corresponding MAZDA C lamp of present standard light center length (see table, in Article 3), the filament center will be cut off from view at an angle of 72½ degrees from the vertical axis (17½ degrees below the horizontal). The mean angle of cut-off for a group of reflectors shall not depart from the specifications by more than 1½ degrees, nor individual samples by more than 2½ degrees

Where reflectors having 2¼-inch fitters are supplied without holders they shall be so proportioned that the correct light center position will be obtained when used with the so-called "O" holder, which positions the top edge of the reflector ¾ of an inch below the center contact of the socket.

Art. 3. Diameter—For each size of reflector, the effective diameter (i e., the diameter of the surface well illuminated by the direct rays of the lamp) shall not be less than the values given in the final column of the following table. For convenience, the light center lengths of the MAZDA C lamps and the nominal over-all diameter of reflectors are also included.

Reflector Designation	MAZDA C Lamp Watts	Light Center Length Inches	Nominal Diameter	Effective Diameter
Dome 50	50 (White)	3¾	12	11¼
" 75	75	4 5/16	12	11¼
" 100	100–150	5 3/16	14	13¼
" 200	200	6	16	15¼
" 500	300–500	7	18	17
" 1000	750–1000	9½	20	19

Art. 4. Contour—The Contour shall be such as to avoid undue concentration of light beneath the unit That is, on photometric test, after the bare lamp candlepower values have been subtracted from the curve of the reflector, the ratio of the maximum candlepower between 0 degrees and 15 degrees and the average of the candlepower values at 25, 35 and 45 degrees must not be greater than 1.35

Art. 5. Efficiency—The design of the reflector, reflection factor of porcelain-enamel, etc., shall be such that, with the lamp filament so located as to give an angle of cut-off of 72½ degrees, the output of the complete unit shall be approximately 75 per cent or more of the light generated by the bare lamp The minimum acceptable light output under the specifications shall be 70 per cent.

Art. 6. Acceptance Criterion—In judging the acceptability of any group of reflectors under these specifications a reasonable number of samples selected at random shall be examined, and if it is found that an appreciable number fail to comply with the specifications, the inspection shall be continued until a thoroughly representative sampling of the entire lot of reflectors involved has been completed. If more than 5 per cent of the samples so tested fail to comply with the specifications, the group of reflectors shall be considered inferior to these specifications. In view of the variability of the reflection factor of porcelain enamel and other possible deviations, the output of a manufacturer cannot be recognized as complying with these specifications unless checked at least four times a year by a thorough inspection and test of his stock, made as outlined above.

AMENDING SPECIFICATIONS

These specifications may be amended and additional standard specifications adopted from time to time by joint action of the Research Laboratories of General Electric Company and the majority of the number of manufacturers whose product is at that time being regularly inspected, as provided in Article 2, by the Electrical Testing Laboratories

RESEARCH LABORATORIES
GENERAL ELECTRIC COMPANY,
SCHENECTADY, N. Y

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Electrical Testing Laboratories issue inspection-approval labels to such manufacturers as accept the uniform contract (thereby agreeing to maintain the quality) when the product has been found by inspection and test to comply with the specifications.

The wide popularity of the "RLM Standard Dome" reflectors is attributed principally to the following characteristics which are called for in the specifications on page 108.

All of these features were coordinated with a view to securing the highest practicable efficiency compatible with reasonable diffusion and proper distribution, based on rather extended experience in the industrial lighting field.

The aim of the originators was to meet the needs of the general run of industrial lighting problems. It is understood that there are special cases where some other type of equipment might be more desirable. For example, in some processes where minute detail must be carefully observed, it may be desirable to have a higher degree of diffusion than that produced by the RLM Standard Dome reflectors, even when used with the bowl enameled lamp, and it is not presumed to be within the scope of the RLM Standard Dome reflector to cover such cases.

Signed jointly by
G. H. STICKNEY and WARD HARRISON.

Mr. Stickney is illuminating engineer of the Edison Lamp Works of General Electric Company at Harrison, N. J., and Mr. Harrison is illuminating engineer of the National Lamp Works of General Electric Company at Cleveland, Ohio.

* * * *

The registered trade-mark RLM on a reflector means that the reflector bearing this label has been made in accordance with the Reflector and Lamp Manufacturers' specifications. Previous to the adoption of this standard, different manufacturers made reflectors in conformance with each individual engineer's ideas as to what constituted a correct reflector. In fitting lamps to these reflectors, the lamp manufacturers found that these reflectors did not always give the best results, and to solve the problem the engineering departments of the lamp manufacturers called a conference of the various reflector manufacturers for the purpose of designing a reflector which would give maximum lighting efficiency with elimination of glare. The reflectors designed as a result of this conference bear the label "RLM." The association of manufacturers making these at first numbered five members. At present there are at least eight.

These manufacturers then made arrangements with the Electrical Testing Laboratories of New York City for periodic inspections of their products to see that they conform



Certificate of Inspection Service issued by Electrical Testing Laboratories, New York City.

to the standards adopted. The inspections are made four or five times a year, and in the event of a certain percentage of the reflectors being found not conforming to the standard specifications, the test certificate or label privilege on that particular type is refused.

The purchaser of a reflector bearing the RLM label is assured of getting a reflector which will give him the maximum amount of reflection when used with the size of lamp for which the reflector was designed.

Supt. Electrical Dept., P. JUSTUS.
Chandler Motor Car Co.,
Cleveland, Ohio.

* * * *

In answer to F. E. G. as to the meaning of R. L. M. Standard Dome Reflectors, I quote the following from the Railway Engineers' Handbook: "After extensive investigation and study, standard specifications covering metal reflectors of the dome type for general illumination have been drawn by the leading manufacturers, and have been issued by the Research Laboratories of the General Electric Company, in which the Mazda service is centered. These specifications, known as the Reflector and Lamp Manufacturers' Standard (RLM Standard) provide: (a) a durable and highly reflecting surface; (b) a contour of reflectors which will insure an effective light distribution; (c) a diameter and depth for each size which will produce adequate diffusion of light and a sufficient screening of the source to minimize glare. Reflectors which comply with these specifications bear a statement in the form of a certificate of inspection service over the signature of the Electrical Testing Laboratories of New York."

Kenova, W. Va. W. A. BIBB.

* * * *

Trouble From Grounded Circuit.—Recently we were asked to look over a motor circuit for a school which had grounded all of the radiators in the school house. It was a 3-wire, 110-220-volt line entering the building in conduit with a grounded neutral on a pipe. We cut this ground and rung out the circuit and found no other grounds. As the motor does not run mornings we went away only to be called again in the afternoon. This motor is bolted on two pieces of wood in cement and has been running for four years and never given any trouble until this Spring. All the rest of the wiring was O. K. and we let the job go. There has never been anything done as the janitor gave instructions to keep hands off the radiators. What could be the possible cause of this trouble?

Saranac Lake, N. Y. L. J. R.

In regard to the trouble from a grounded circuit mentioned by L. J. R. in a recent issue of INDUSTRIAL ENGINEER, I presume the complaint was that a person would receive a shock upon touching a radiator. This would be possible if the radiator system were insulated from the ground, either by design or by a high resistance pipe joint, and then became "grounded to" (in contact with) a live wire. In any case this complaint may be eliminated by grounding the radiator system to a large underground pipe system, to a good ground, or to the neutral of the three-wire system. The ground on the three-wire system should be replaced at once as its absence may cause someone to receive a serious shock. With a grounded neutral the greatest voltage that can be obtained between a live wire and ground is equal to the voltage from the neutral to either outside wire, while with an ungrounded neutral the full voltage between the outside wires may be obtained if an accidental ground is present.

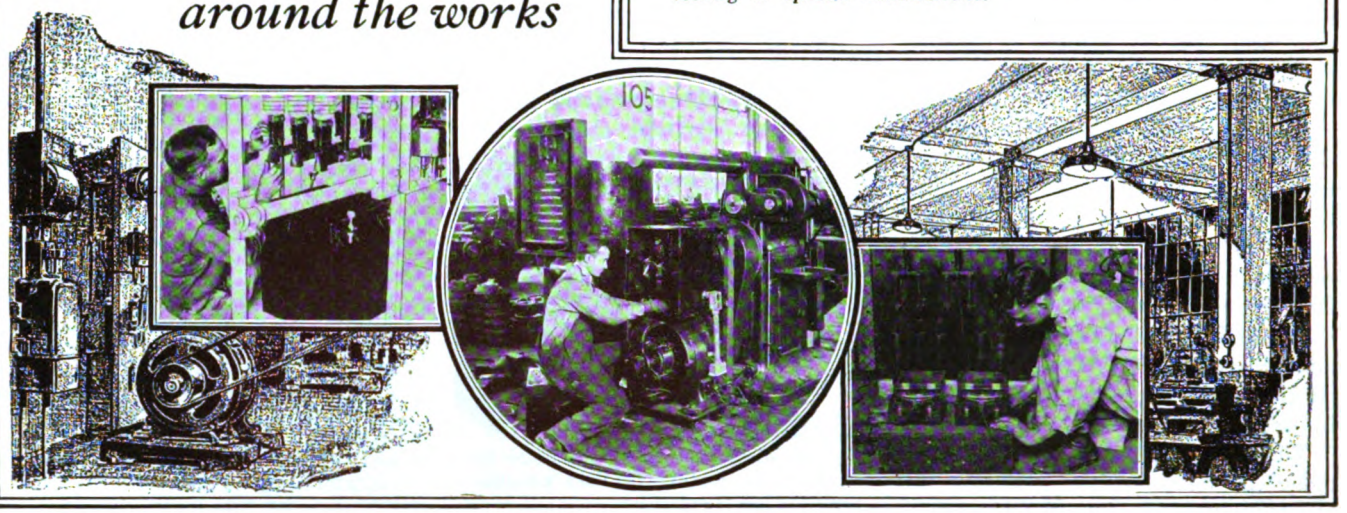
If the trouble occurs only while the motor is running, then look for a grounded motor and insulated radiator system accidentally touching an outside wire. Open the main switch and with the motor off ring out between each outside line and the radiator system. If clear, then ground as stated before. Then with the motor switch open, ring out between each wire on the motor side of switch and the ground. The motor should be cleared of grounds.

Summit, N. J. VICTOR H. TODD.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



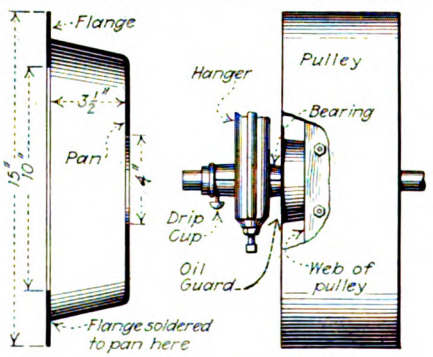
How to Get Better Service from Flashlight Cells by Cleaning Contacts

I HAVE found that a pocket flashlight battery is indispensable in my work and I carry one with me constantly. I have often noticed, however, that the light would be dim sometimes and bright at others, and putting in new cells frequently did not remedy this condition. Again, the light would go out at times but could be restored by simply jarring the holder which contains two cells arranged, as usual, so that one brass positive carbon tip touches the lamp while the bottom of the cell is in contact with the tip of the next cell, whose bottom is in spring contact with the bottom of the holder. Investigation generally showed all of the contacts to be in apparently good condition. Although the bottoms of the cells were of the color of lead, they would appear to be very clean and anyone would say that the contacts were perfect. I have found that this is not the case, for by simply scraping the cell bottoms so that they showed the bright zinc, all of the troubles from dim lights were completely eliminated. In fact, the lights burned brighter than ever before because there was less voltage drop due to the resistance occasioned by the oxidized condition of the metal. Heretofore, I have thrown batteries away after short use, thinking that they were no good, when I could have obtained considerably more service from them. The moral is, scrape the contact surfaces of the flashlight cells when they are first placed in the holder, and occasionally thereafter. HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

Guard on Pulley Keeps Oil Which Escapes From Bearing From Saturating Belt

TO PREVENT oil from reaching a belt the guard shown in the accompanying drawing is used in a St. Louis shop. Ordinarily a drip cup would be used to catch the waste oil, but in this case there was not room for a drip cup because on account of space limitations, the driven pulley had to be set almost in contact with one of the end shaft hangers, as shown in the drawing. As a result, the oil that oozed out of the bearing dropped on the inside of the pulley rim and flowed to the face of the pulley. In this way the belt became saturated with oil. The oily condition of the belt did not appreciably impair the grip on the wooden driven-pulley, but it did result in continual slipping on the face of the iron driving pulley.



The sheet-iron guard at the left was fastened to the web of the pulley as shown at the right.

The difficulty was overcome by attaching a tin oil guard of the form shown in the vertical cross-section. The end hanger was taken down and the guard was slipped over the end of the shaft. It was fastened with wood-screws to the web of the pulley.

Now all of the oil that seeps out of the pulley end of the bearing collects in the oil guard; none of it reaches any part of the pulley. The oil is occasionally removed from the guard by wiping with a piece of cotton waste. A. J. DIXON.

St. Louis, Mo.

Simple Method of Mounting Starters for Motors of Individually-Driven Machines

OVERHEAD mounting of starters and other equipment often possess many advantages such as are shown by the illustration on the next page which shows two profiling machines direct-connected to two 2-hp., 3-phase, 60-cycle, 440-volt, 1120 r.p.m. induction motors, with the motor control equipment consisting of Iron-Clad safety motor starters mounted on standard channel-iron supports on the ceiling, directly over the machines. The starters are placed so that the operating chains can be conveniently reached by the machine operator.

We use this type of starting equipment on motors up to and including 7½ hp. Where there is no room

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available on the machine to mount the standard double-throw switch, these starting switches are mounted on the same channel-iron supports that are used for mounting the standard oil-immersed auto starters and switches which are used on large motors.

F. W. McGRAW.

Swissvale, Pa.

A Practical Method of Making a Load Test on Direct-Current Motors

HOW to conduct a heating test on a direct-current motor is a question which occasionally confronts the repair man or plant electrician. With it are often associated the problems of correctly setting the brushes and of adjusting the interpoles on a repaired interpole motor. In the case of a motor which has been rewound for a voltage, horsepower, or speed different from what it was originally designed for, these matters are quite vital if the motor is to give satisfaction in future use.

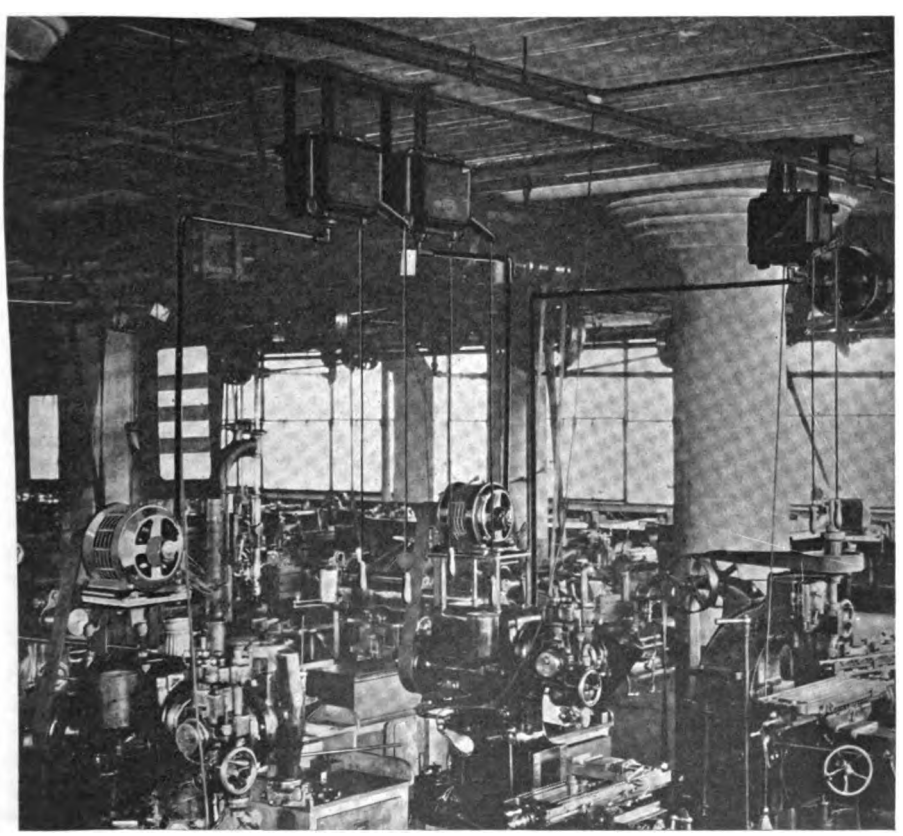
There are several ways of making the heat run or load test as it is called, but the loading-back or pumping-back, two-motor method is probably the most satisfactory. The following procedure has been used often and with uniform success in a certain large manufacturing plant. There are several different hook-ups to be found in various hand-books, but most of them omit important items or leave them to be inferred by the reader, thus causing the inexperienced tester much trouble.

In the diagram on the next page, it is seen that the motor to be tested is mechanically connected to the loading motor. This connection may be by means of pulleys and a belt, chain drive or direct connection through a solid or flexible coupling. If there is available a motor of the same size, speed and voltage as the one to be tested, it should be utilized as the loading motor. However, if such is not the case, a motor should be secured of such rating that when it is being driven by the motor under test it will develop a voltage which will be adjustable, by means of a field rheostat, from a value about equal to that of the supply line to a value about 10 per cent over it, and which will be able to carry the same current as the motor to be tested. For instance, a test was recently made of a 115-volt motor by loading-back with a 230-volt motor. The 115-volt machine was rated, 450-900 r.p.m., 100 amp., and the 230-volt motor had a rating of 650-1000 r.p.m., 100 amp. When connected up for test and driven at 900 r.p.m. (the speed at which the 115-volt motor was to be tested), the 230-volt motor was made to develop the proper voltage by manipulation of the rheostat in its field, which, of course, was on 115 volts. However, the case could not be reversed, that is, the 230-volt motor could not be tested as such by loading-back on the 115-volt machine without inserting considerable resistance in series with the field of the latter. The exercise of common sense in the selection of the loading motor will nearly always result in the securing and proper connection of a motor which will serve the purposes of the test.

The instruments required are an ammeter, and a voltmeter, together with some means of determining the speed of the motors. Two additional ammeters may be used to advantage in the line circuit and the field circuit of the tested motor as shown in the diagram. If only one ammeter is used it must be of sufficient capacity to carry the greatest amount of current to be taken by the motor under test. The other two ammeters, if they are used, may be of a lower range.

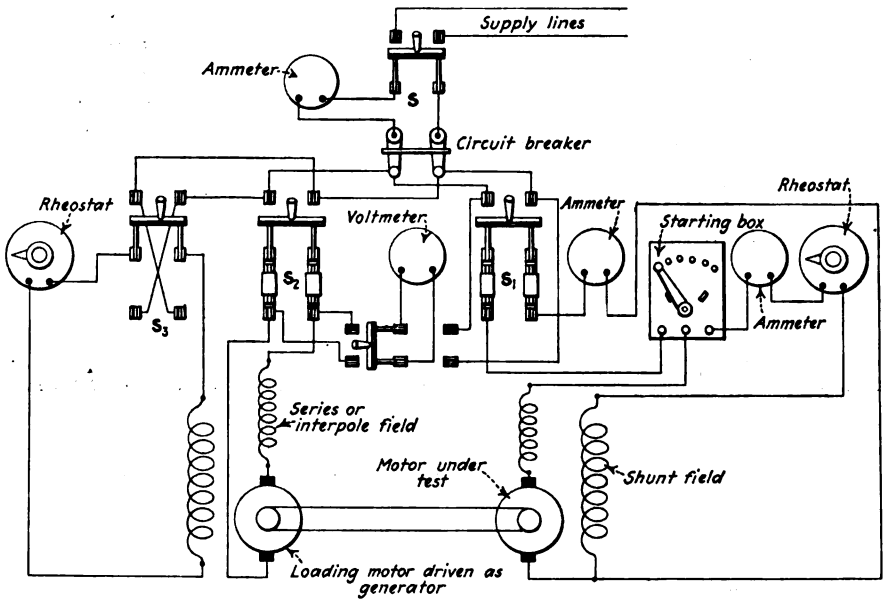
When the motor to be tested is properly coupled to a suitable loading motor, connect the various circuits as shown in the diagram. Care must be taken to have the supply line protected by a circuit-breaker or by fuses arranged to interrupt the circuit at about 50 per cent of the maximum current intended to be taken by the motor under test. For example, in testing a motor which will be loaded so as to take 60 amp., set the circuit-breaker to trip or use fuses rated at 30 or 35 amp. The starting-box must be of sufficient capacity to carry the full-load current for the duration of the test and also any overload that it is intended to impose on the motor under test. The fuses on the motor switches, S_1 and S_2, must be of the same rating as the motor to be tested plus the per cent overload to be given.

It is to be carefully noted that one ammeter must be connected in the circuit on the motor side of the supply line. This location of the ammeter enables it to indicate the full load on the motor and makes it possible to test with only one high-reading ammeter. Were this meter placed on the driven motor side of the supply tap, it would indicate only the current supplied by the generator action of the driven motor. This current is the total current through the driven motor less the current drawn from the supply line.



Arrangement whereby motor starters are mounted overhead.

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This is the way to connect the motors for a load test by the pump-back method.

When the two switches, S_1 and S_2, and the voltmeter are coupled in as shown, the line voltage and the voltage of the driven motor can be easily compared by throwing the double-pole switch from one side to the other. In case of unexpected trouble, pull switch S or both S_1 and S_2 or trip the circuit breaker.

By coupling the two switches, S_1 and S_2, and the voltmeter as shown, the line voltage and the voltage of the driven motor can be easily compared by throwing the double-pole switch from one side to the other.

The test is conducted by closing the switch S_1 and manipulating the starting-box to start the driving motor. Adjust the speed of the latter by means of its field rheostat. This rheostat may be a few standard resistance tubes in parallel, shunted by a small knife switch which is to be closed during starting. Adjust the brushes of the tested motor and see that everything is running smoothly. The brushes on the driven motor should be set at approximately correct position unless they have already been so located.

Next close S_3, which will energize the field of the driven motor. Try the polarity of the voltage generated by throwing the double-pole voltmeter switch to the S_2 side; check with the line voltage, and if the polarities are not the same, reverse S_3. Then build up the voltage generated by the driven motor until it checks to within 2 or 3 volts of the line voltage. Now, and not until now, close S_2. The inexperienced tester must be warned against closing S_2 at any other time than when the above conditions exist. A short-circuit through the armature of the driven machine is apt to result if this switch is closed otherwise. Also, the switch S_3 must never be opened before opening S_2. Short-circuit phenomena are again invited by this action due to throwing the armature of the driven motor across the line without a field.

When S_2 is closed as directed, the ammeter will show hardly any change in reading and both motors should continue to run smoothly and at unchanged speed. Then commence to cut out the field resistance of the generating motor. Do this very slowly, giving time for conditions to settle after each increase in load current as indicated by the meter. In this matter it is to be noted that when testing motors which have a wide range of speed obtainable by field weakening (commutating or interpole motors) it is necessary to have a very finely divided field rheostat in the field circuit of the loading motor. Unless the rheostat is of the type mentioned when motors such as are referred to are being tested the large changes in field strength will produce such great changes in voltage as to cause violently rapid loading of the tested motor with possibly dangerous overloads or a short circuit between the two armatures.

After the required load current has been reached, speed readings should be taken and commutation observed and carefully recorded, together with the time at which the motor reached full load. As the rheostats heat up and their resistances increase accordingly, the load will decrease slightly; this can be compensated for by a readjustment. The load will remain quite steady however, regardless of slight fluctuations in the supply voltage. It will be noted during the progress of the test that the tested motor is considerably warmer than the generating motor. This difference in temperature may be a matter of much concern at first glance if the two motors are identical, but it is natural and not necessarily indicative of trouble.

Upon completion of the load test or heat run, the load may be removed in small steps and speed, voltage and current, readings taken at each step. This will take but a few minutes and will give the data for the valuable speed-load or regulation curve of the motor. Do not decrease the load current too quickly, nor to a smaller value than it had at the beginning of the loading operation. It is better, in fact, to unload to not less than 10 per cent of the full-load current, then open S_2 and finally, to stop the motors, open S_1. If the supply switch S is near at hand the two motors may be stopped by opening it when the load is down to this value. Temperature readings on the various parts may now be made if information is desired on the final rise in temperature.

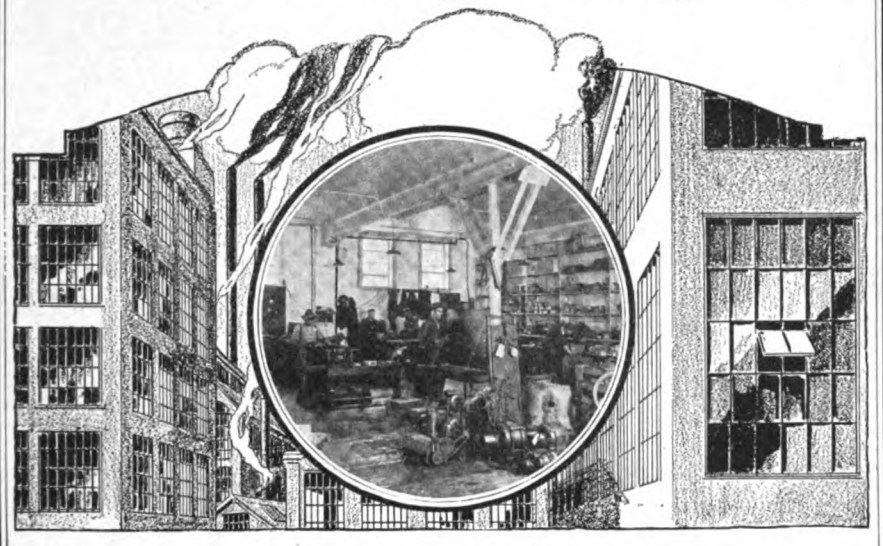
Keep a cool head and in case of unexpected trouble necessitating stopping the motors, pull the switch S, or trip the circuit-breaker if either are near at hand. If they are not, pull both switches S_1 and S_2. Both must be pulled to stop the testing set, as if S_1 only is pulled, the generating motor will continue to run as a plain motor.

If it is desired to determine the efficiency of the motor under test the resistances of the field and of the armature circuits should be measured immediately after getting the temperature readings. These in connection with the values of field and motor amperes observed during the test will give data for the calculation of the copper losses. The stray-power losses may be determined closely enough by disconnecting the two motors and running the motor under test idle at the same speed it had during the test, noting the voltage and the amperes input. The product of these two quantities less the copper losses as calculated for the running-idle amperes will be the stray-power loss. The calculation of the efficiency is then a simple matter.

Gurney Elevator Co., Honesdale, Pa. J. M. WALSH.

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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welocme.

Improvised Press Used to Force New Lining in Pump Cylinder

RECENTLY we had occasion to reline a boiler feed-water pump which suddenly developed trouble. The piston, piston rod, stuffing box and gland were first removed. A wedge was then driven between the old lining and the cylinder wall for the entire length of the lining. Into the gap thus formed a crowbar was inserted and forced down until the lining buckled in the middle. The lining was then easily drawn from the cylinder.

A collar *A* was then turned out on the lathe, the outside diameter being made just an easy fit for the inside of the cylinder. A flange was next turned in the collar so that this smaller diameter fitted snugly inside the new lining. Through the center of the collar a 1¼-in. hole was drilled.

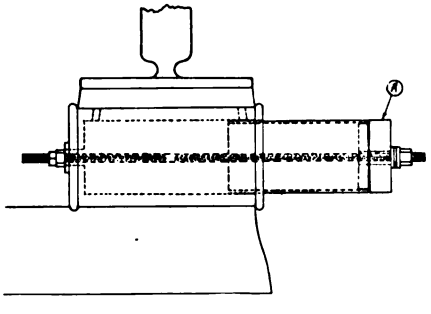
A long rod of good quality steel, 1 in. in diameter, was then threaded throughout its entire length and passed through the cylinder. This rod had on the farther end a ½-in. iron plate which also had a 1¼-in. hole drilled through it. Holding the plate in place were two heavy nuts.

The new lining was then slipped over the projecting rod and tapped lightly until it had a slight start in the cylinder. The collar was then fitted in place as shown and several heavy washers placed on the rod, the whole being finished by screwing on an extra heavy nut.

The entire surface of the new lining was then generously smeared with white lead and the nut forced on with a large wrench. When this is done care must be taken in passing over the head-end port to see that the edge of the lining does not catch on the farther edge of the port opening. The nut must not be screwed up too quickly at first, as excessive pressure might buckle the lining. Plenty of oil should be kept on the nut and washers to reduce friction as much as possible, and the the sleeve should be continually tapped with a mallet. When the lining is almost in place it should be watched closely so that it will not be forced in too far, and so obstruct farther port opening. If the collar passes into the cylinder so far as to make it difficult to ply the wrench, remove the nut and build up with washers. If the rod shows a tendency to turn with the nut, apply a Stillson wrench at the farther end.

After the lining has been adjusted to its proper place, the pump should be assembled again and new packing placed in the stuffing box and around the piston. JAMES P. MARSHALL.

Boston, Mass.



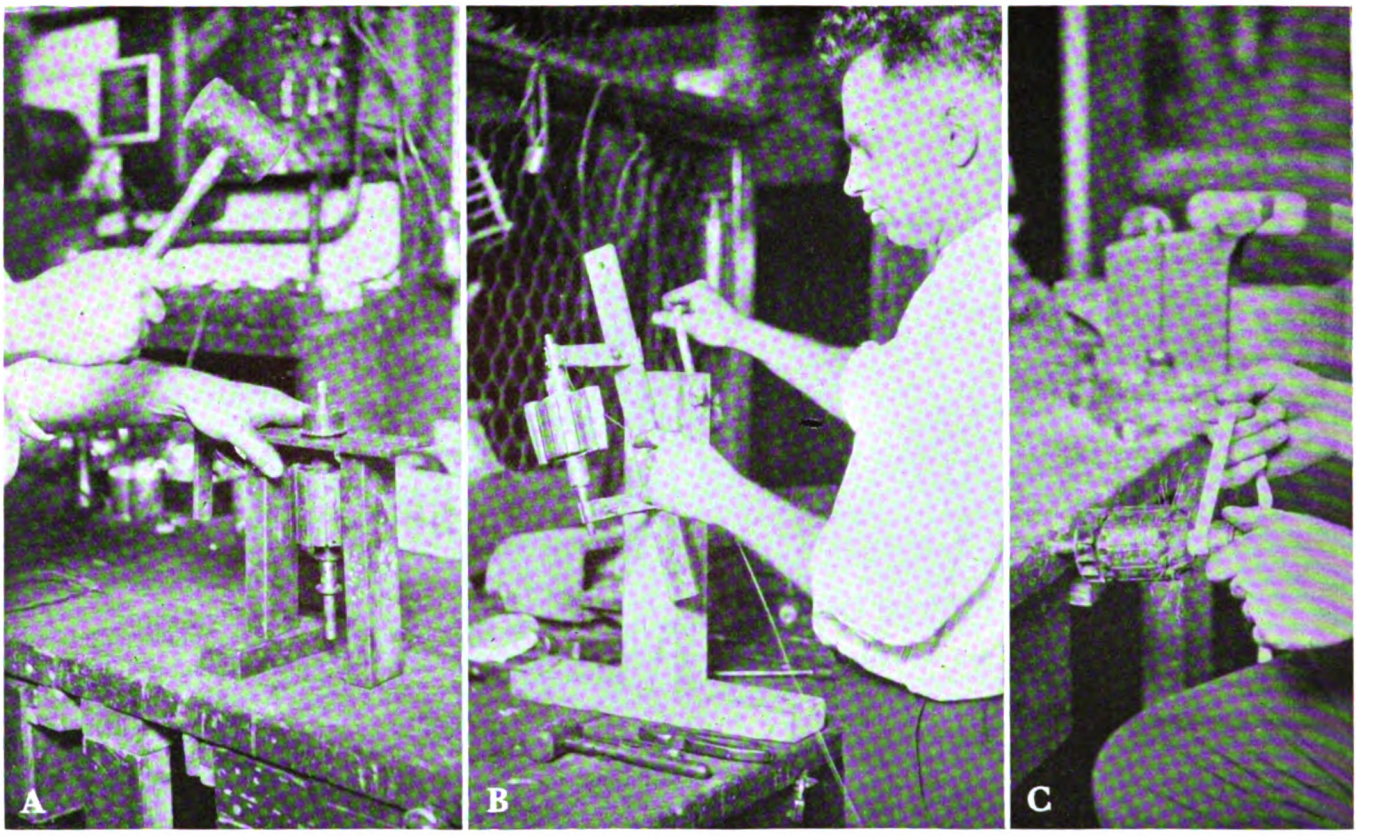
Precautions to take when forcing a new lining into a pump cylinder are explained in the accompanying item.

Simple Devices Which Are Useful in Winding Small Armatures

THERE are several simple and easily made devices which I have found can be used to advantage in rewinding hand-wound armatures of small motors. An armature to be rewound is first stripped, the number of coils per slot and the number of turns per coil counted, and note taken of the throw of the armature leads for the commutator connection. After all the wire has been removed and the insulation gaged, the distance between the commutator and the end of the shaft is measured, and the commutator removed from the shaft. This can be done in the manner shown in an accompanying illustration by suspending the armature on two flat pieces of steel which are placed under the commutator and supported on wooden uprights. By pounding on the end of the shaft with a rawhide or lead hammer, the commutator can be easily forced off. If desired, a clamp with a setscrew can be used for this purpose; the clamp should fit behind the commutator and by turning the setscrew a sufficient pressure can be exerted on the end of the shaft to pull the commutator off.

When the armature is ready for rewinding, the shaft and core ends are re-insulated with empire cloth, which is cut circular with an opening for the shaft and then slipped on like a washer, and shellacked to the core end. The shaft is insulated by wrapping it with tape outward from the end of the core. This insulation is extended along the armature shaft farther than is necessary and then is cut close to the winding when the job is completed. For slot insulation I use 10-mil leatheroid on 110-volt motors and on 220-volt motors 10-mil leatheroid with one sheet of empire cloth. The slot insulation is cut ¼ in. longer than the length of the slot, thus allowing the insulation to over-

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Three steps in rewinding armatures of fractional horsepower motors.
A—Removing commutator by pounding with rawhide hammer on end of shaft, while the armature is suspended on two flat iron bars supported on wooden uprights. *B*—The base of this winding device is a piece of 2-in. by 4-in. wood, while the upright is a piece of 4-in. by 4-in. The shaft and crank of the rotating part are made of iron. The bar which supports the armature is a piece of ½-in. by 2-in. iron, about 18 in. long. The holding clamps are of light strap iron, 4 in. to 6 in. long. *C*—Cotton tape is wound around the armature shaft to fill the space between the commutator and winding and give a firm support for the fine commutator leads. After the leads have been soldered in place they are bound down with string.

lap the core and protect the winding from the corners of the slot. When winding, care must be taken not to cut this insulation with the wire. The insulation for the slot should extend ½ in. over each edge of the slot, in order to allow the wire to be guided into place with ease.

For winding the armature the simple winding machine shown in the accompanying illustrations will be found convenient. As will be noted, the upright and base can be made of 2-in. by 4-in. lumber, or of pipe and pipe fittings if desired. The flat piece of steel supporting the armature is ¼ in. thick, 2 in. wide and about 18 in. long. It is firmly attached in the center to a short piece of pipe, or bar, which passes through the bearing in the upright and on the other end is fitted with a crank for turning the armature. Two clamps are used to support the armature. These clamps are 4 in. or more long, depending on the size of the armature core.

The winding machine is placed on one end of the bench and a stand for holding the reel of wire is placed on the floor. Of course, the same size of wire and the same kind of insulation should be used for rewinding the armature as were formerly employed, unless there is some good reason for a change. A micrometer or a wire gage may be used to determine the size of wire previously used in the armature, and the type of insulation may be determined by inspection and measured for thickness.

After the proper wire is selected and put on the reel stand, the end of the wire is loosened from the reel and a foot or so is cut off with a pair of pliers. This is done to eliminate the use of stretched wire, for when fine wire is put under tension it stretches until it becomes under-sized. After the stretched section is cut off, a piece of sleeving the length of the armature lead is slipped over the end of the wire.

If there are twelve slots in the armature the span of a coil will be from 1 to 6. Starting at the commutator end of the armature, the first armature lead is fastened to one of the clamps of the winding machine or secured in a slot of the armature.

The armature is then turned by means of the handle of the winding machine and the wire guided into the slot until the required number of turns have been applied to complete one coil. The end of the coil is carried to the next slot, but before again starting to wind, a few inches of wire are allowed for the armature lead and twisted into a loop. Then the next coil is started, and so on until all of the coils have been wound.

The last coil ends where the first coil began. The sleeving of the armature leads can be done either while winding or after the winding is complete. A thin strip of fiber can be used to force the wire into the slots in case there is a very close fit at the core edges.

When two coils are placed in one slot the armature leads can be marked for commutator connection by making an extra number of twists in the end of the loop. After completing the winding, the insulation is trimmed and either fiber wedges are put in the slots to hold the wire in place, or band rings are wound around the armature core. The open ends of the windings are then connected to a test set to detect

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grounds. If a ground is present it will probably be found at the slot end. Such grounds may be cleared by pushing the wires back and inserting between the wire and the core end a small piece of insulation covered with shellac. The commutator is next pressed onto the shaft and the armature lead brace put between the armature winding and the commutator. As shown in one of the illustrations, this is done by winding cotton tape around the armature shaft to a sufficient depth to fill the space between the commutator and the winding. This gives a firm support to the fine wires and prevents them breaking off.

The armature leads are then brought down to the commutator and soldered in place, care being taken to see that the leads have the same throw as in the old winding. After the wires are soldered in place they must be bound down against the tape supports with a string band.

For testing the armature for open circuits and shorts, a telephone receiver is employed, the ends of the receiver cord being placed across two bars. Current is supplied through a lamp bank to two nails which are driven in the bench and touch each side of the commutator. The ends of the telephone receiver cords are moved over two segments at a time, and from the character of the sound in the receiver the nature and location of trouble in the armature may be detected. Open circuits produce a very loud noise, while with short circuits no sound can be heard. When all of the bars give a uniform sound, the armature can be considered to be all right.

After the rewound armature has been tested and any defect found present removed, it is then shellacked and baked for three hours, or if preferred, an air drying insulating paint may be used. If necessary, the commutator may then be turned down or smoothed and the armature is ready for use.

For coil-wound armatures the coils can be made on the winding machine by placing two screws in the steel plates and putting insulation over them so that covering of the wire will not be injured. After winding, the loops are bent into the proper shape and placed in the armature.

Chicago, Ill. H. E. EWALT.

Size of Wire for Alternating Current Motor Leads and Jumpers

WHEN repairing a motor new leads and jumpers are often put on. The sizes of rubber-covered wire to use for this purpose are given in the accompanying table and apply to motors of 100 to 600 volts, one, two or three phases, and twenty-five or sixty cycles.

The table gives the sizes for a series connection of the winding. With a winding connected in parallel the leads would be the same but the jumpers would be smaller. For a two-parallel winding the rated amperes should be divided by two and the jumpers taken which correspond to this current. Likewise for a three-parallel winding, the amperes should be divided by three and so on.

Size of Rubber-Covered Wire for Jumpers and Leads of A.-C. Motors

These sizes apply to motors of 100 to 600 volts, 25 to 60 cycles, and one, two or three phases.

Rating of Motor, Amp.	*Jumpers, B & S Gage No.	Leads (Flexible Cable)	
		No. of Conductors	B & S Gage No.
1 to 6	16	19	27
7 " 15	14	19	27
16 " 20	12	19	25
21 " 25	10	19	23
26 " 35	8	19	21
36 " 50	6	49	23
51 " 70	4	49	22
71 " 80	3	61	21
81 " 90	2	7	11
91 " 100	1	19	14
101 " 125	0	19	13
126 " 150	00	19	12
151 " 175	000	19	11
176 " 225	0000	19	10

*The values given are for series-connected windings. For two-parallel windings, divide rated amperes by two and use jumper corresponding to this current. For three-parallel, divide by three; for four-parallel, divide by four, and so on.

For example, if the winding of a motor rated at 50 amp. per terminal is series-connected the jumpers will be No. 6 and the leads a flexible cable of forty-nine No. 23 conductors. If the motor rated at 50 amp. has a two-parallel connection, the leads will still be a cable of forty-nine No. 23 wires. To find the size of the jumpers, however, divide the amperes by two (50÷2=25) and look for the jumpers required for this current, 25 amp. In this case the jumpers would be No. 10.

For a 63-amp. motor with three-parallel winding, the leads will be cables of forty-nine No. 22 wires. The jumpers (for 63÷3=21 amp.) will be No. 10.

In the last case a No. 12 jumper could be used instead of a No. 10 without danger. In fact a margin of 3 amp. is allowed. For instance for 83 amp. a No. 3 jumper could be used without any bad effects.

Detroit, Mich. A. C. ROE.

Hand-Whittled Wooden Screwdriver Facilitates Assembly of Small Parts

FREQUENTLY it is necessary to assemble devices under very difficult and trying conditions, for instance, holding parts and at the same time inserting screws in holes which are hard to reach. When I have a job like this I make a wooden screwdriver of either hard or soft wood, and of a size to suit the conditions, and cut the point so as to make a press fit in the screw slot.

Such a driver will hold the screw nicely and will usually have strength enough to start the screw, after which it can be sent home with a metal driver. I have used this scheme for several years and find that it saves much time and effort as well as patience.

I have made drivers from an ordinary match for use on small work and from scrap pieces of wood which can always be found around the plant, for other work, and find that they beat anything I have ever tried in the way of spring point screwdrivers, using soap on an ordinary driver and various other familiar devices for doing miscellaneous jobs of this sort. In case of an emergency they can be made on the job in a few moments. HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.
Patchogue, N. Y.

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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Handling 40 Tons of Loose Screw Machine Turnings Daily From the Shop to Pit Storage by Tractor and Trailers

ONE OF the subjects that was given a great deal of attention by the National Acme Company, Cleveland, Ohio, when it erected its new screw-machine products plant, was the handling of scrap. The method finally adopted for taking care of this material has proved both convenient and economical, and is a decided improvement over the method formerly used of handling scrap in wheelbarrows.

The company produces in its plant over 40 tons of scrap per day. The scrap is all turnings, which are bulky in form. The day's output in screw-machine products and turnings is scraped out from beneath the machines at night in order that a full day's work can be done on the automatics during the daytime. The material is placed in steel buckets about 8 in. in diameter and 14 in. deep. In the morning the buckets are dumped into oil separators, and after the oil is extracted the product and scrap go to the chip separators. From these the product passes on through washing machines to the inspection department. Every machine is numbered and a large sheet-iron tag bearing this number travels with the work until the product is weighed and recorded. Then the tag is sent back to the machine from which it came. This prevents similar parts from getting mixed and makes it easy to identify them.

The turnings are shoveled from beneath the chip separators into dump-hopper trucks. Six of these trucks are used and one Elwell-Parker Electric and Manufacturing Company's (Cleveland, Ohio) storage battery tractor is provided for hauling the trucks. Usually the tractor hauls two loaded trucks on a trip. The capacity of each truck hopper is 40 cu. ft., or approximately a ton of turnings.

The scrap is hauled outside the building and dumped into a concrete pit 200 ft. long, 25 ft. wide and approximately 12 ft. deep, which has a capacity of about 30 carloads of turnings. This pit is built in the platform alongside of two railroad tracks at the side of the plant. These tracks also serve the raw-material receiving department. Sufficient space is provided for running the trucks on either side of the pit. From the pit the scrap is loaded on cars by a locomotive crane equipped with a grab bucket. It takes only about 30 min. to load a standard railroad car. The crane is electrically operated, the electrical connection being made through plugs located near the track in the platform. A railroad scale is located in one of the sidings for weighing the empty cars and loads of material.



This electric storage battery tractor hauls two trailers loaded with turnings, from the plant to the storage pit where they are dumped.

The truck hoppers each have a capacity of approximately one ton and dump their loads into a concrete pit of 30 carloads capacity. An electrically operated locomotive crane can load a standard railroad car in about 30 min. with a grab bucket. Because these turnings tangle so badly, it would be difficult for a gang of men to take them out of the pit.

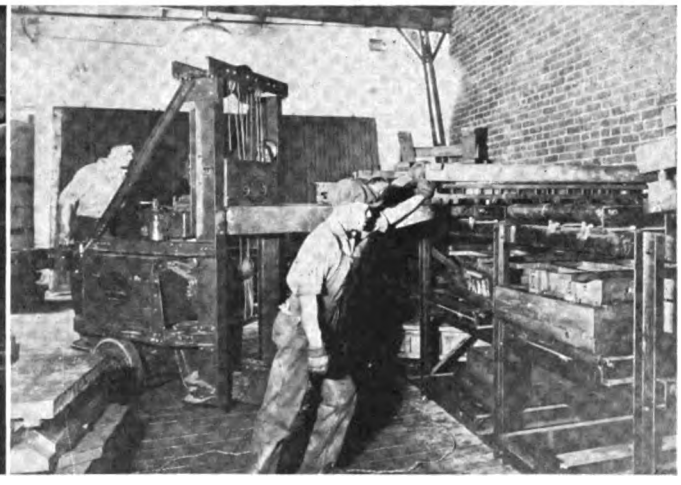
Reducing a Job From Several Hours to a Few Minutes

AMONG the jobs around a shop, which men who have introduced efficient material-handling equipment have found that they can make a big reduction in costs, is the handling of dies to and from presses and storage. With ordinary methods of doing this work, this job would require a gang of four or five men several hours. This would mean, in addition to the labor involved, a loss of production of the press which, according to its size, might vary

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Doing a 3-hour job in a few minutes.
Instead of spending several hours in changing dies and thus holding up production on the press, two men can change a die in just a few minutes. The truck not only removes the old die but also brings the new one from storage.



Putting the die in storage.
Roller conveyor sections in these die storage racks make it easier for the operator to insert or remove dies. Racks three high as in this case also economize in storage space. In addition, dies carefully stored in racks are less likely to be damaged than if piled in a haphazard manner and are more easily kept track of.

from $5 to $25 or more an hour.

At the Detroit plant of the Fisher Body Company, idle time of the presses due to changing of dies has been reduced to a minimum by the use of a Baker R. & L. "Hy-Lift" or tiering truck shown in the two accompanying illustrations. The illustration at the left shows the truck approaching the press ready to pick up on its platform the die which is here loosened and resting on the bed of the press. The platform of this truck can be raised or lowered until it is the exact height of the punch press so that the die can be easily pushed across from one to the other. This requires only a few minutes in contrast to other methods which require special rigging to elevate the die into position and set it on or off the press bed.

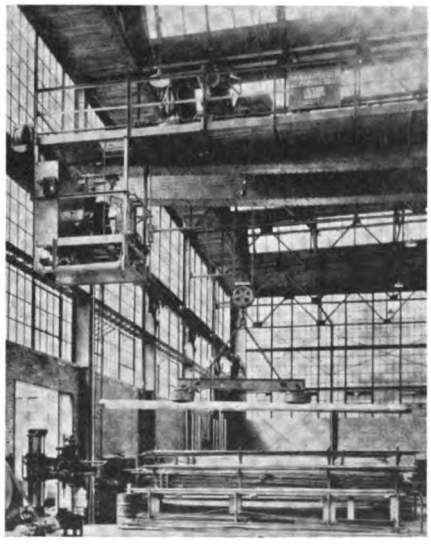
The illustration at the right shows how easily the die may be stored. Here the storage racks are provided with roller sections so that dies may be more easily slid on or off. The platform of the truck may be raised or lowered so as to pick up dies from any of the three tiers in the rack. In the same way they may be as easily replaced in any section.

This has reduced the time off for changing dies from several hours to a few minutes with a consequent saving not only in the labor involved but also, and more important, a reduction of the non-productive period of the press. At other times when not changing dies this truck may be used for handling skid platforms the same as any other lift trucks, or for piling loaded platforms one on the other and so doubling the capacity of the storage space.

This truck has a lifting capacity of 4,000 lb. with a vertical travel of from 11 in. to 72 in. Separate motors are provided for travel and lifting. The platform is raised and lowered through a special two-cable hoist. The Baker R. & L. Company, Cleveland, Ohio, made the installation.

Storage Capacity Doubled by Using Crane and Magnets to Pile Higher

ONE OF the shortcomings of hand-piling is that frequently it requires almost as much space for the men doing the piling as it does for the storage of the material. As this space is also required for unpiling it is in reality just that much of a waste. Also, hand piling seldom, if ever, can be carried as high as mechanical piling. The advantages of mechanical piling are well exemplified in the Chicago warehouse of Kelly and Jones Company. Here a Pawling and Harnischfeger (Milwaukee, Wis.) 10-ton overhead traveling crane is equipped with two 20-in. Ohio Electric and Controller Company (Cleveland, Ohio) round magnets mounted on a spreader beam. Pipe up to 20 ft. in length is handled by this crane and magnet from the car to the pile and also from the pile to the motor truck for city delivery. The two magnets will handle about 1,500 lb. of pipe in lengths up to 20 ft. at a lift.



By piling and unpiling pipe stock with a magnet, aisle space is saved.
In addition, it is possible to pile about twice as high and so more than double the capacity of the warehouse. Two magnets on a spreader bar, as here, make it possible to pick up long pieces with less danger of an accident.

Stakes are set in "shoes" which are placed in the concrete floor. The spacing and height of these stakes determine the size of the pile. As the pipe is lifted in and out at the top of this pile it is not necessary to leave wide aisles as would be essential if it were piled by hand or if it were necessary for the men to get to and from the piles for engaging or disengaging chain slings. The pipe is piled 18 to 20 ft. high, which is about twice as high as would have been possible if it were piled by hand or if chains were used. This additional height and the practical elimination of the aisle has enabled the pipe to be stored in less than half the warehouse space which would otherwise be necessary. One man from the floor directs the operation of the craneman in piling or selecting stock for delivery.

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New Products Made in 1922

(*Continued from page* 103)

the top electrode or through the top electrodes and the furnace hearth. A balanced load results on the transformer primaries in each case.

An induction type of furnace adapted to melting non-ferrous metals has been developed by the General Electric Company. The melting chamber of this furnace in which the charge is received, melted and held for pouring, resembles an ordinary crucible with an enclosed top and with a charging door on one side and pouring valve on the other. Communicating with this chamber through ports is another chamber in the form of a hollow cylinder which encircles a primary winding and one leg of a laminated iron core. Molten metal in this cylindrical chamber constitutes the secondary of a transformer and the heat is generated by the secondary current which flows around the cylinder. The refractory lining is constructed of three parts which are formed and fired before placing inside the furnace. For yellow brass the furnace holds 1,200 lb., with a capacity of 750 lb. Running continuously, the power consumption is 200 kw.-hr. per ton of brass. On 60 cycles the power factor is about 75 per cent.

Three electrically heated furnaces for vitreous enameling have been installed on the Pacific Coast by the Electric Furnace Construction Company, Philadelphia, Pa. Each of these is rated at 210 kw. An electric oven with a wide field of usefulness has been developed by the Despatch Manufacturing Company, Minneapolis, Minn. The oven has a temperature range of 100 to 400 deg. F. and a power consumption of 200 to 900 watts. The oven is controlled by a three-heat switch. It measures 18 in. wide by 14 in. by 14 in. A complete line of small and medium-sized industrial ovens has been put on the market by the Westinghouse Electric & Manufacturing Company. All of these ovens have temperature ranges of 100 deg. F. to 600 deg. F. A line of cartridge-type heaters ranging from ½ in. in diameter and 2¼ in. long to 1 15/16 in. diameter and 8½ in. long with capacities of 100 to 1,000 watts is offered by the same company. A

New Equipment Developed in 1922 for Use in Industrial Works

The number in the right-hand column refers to the page of this article where details are given. The (*) indicates that details have been given in advertisements during 1922 in Industrial Engineer

Equipment	Type or Use	Manufacturer	See Page
Attachment Plug	Armored	Arrow Electric Co.	95
Ball Bearing	Two ball grooves	Standard Steel Bearings Co.	102
Battery Station	Charging outfit	Hobart Brothers	97
Battery Station	Cell filler	Electric Storage Battery Co.	101
Battery Station	Water still	Barnstead Still & Sterilizer Co.	101
Battery Station	Discharge rate tester	Service Station Supply Co.	101
Battery Station	Electrically heated knife	Service Station Supply Co.	101
Bearing Metal	Copper-lead	Stewart Mfg. Co.	*
Blow Torch	Shop	St. Paul Welding & Mfg. Co.	*
Brush Connection	For commutator brushes	Boxill-Bruel Carbon Brush Co.	96
Bunsen Burner	Improved	Henry Heil Chemical Co.	*
Bushings	Reducer for knockouts	Adapti Co.	94
Cable	Fittings for	National Metal Molding Co.	94
Control	Paper-machine drive	General Electric Co.	90
Control	Printing press	General Electric Co.	91
Control	Mill drives	Westinghouse Electric & Mfg. Co.	90
Circuit Breaker	Enclosed	Roller Smith Co.	94
Circuit Breaker	Enclosed	Cutter Company	94
Circuit Breaker	Enclosed for motor starting	Monitor Controller Co.	93
Cord	Dreadnaught portable	Indiana Rubber & Insulated Wire Co.	*
Electric Drill	Portable	Jones, MacNeal & Camp.	93
Electric Furnace	Induction	General Electric Co.	118
Electric Furnace	For vitreous enameling	Electric Furnace Construction Co.	119
Electric Furnace	Steel making	Electric Furnace Construction Co.	118
Electric Oven	Wide temperature range	Despatch Mfg. Co.	119
Electric Oven	Small size	Westinghouse Electric & Mfg. Co.	119
Electric Welder	High current value	Westinghouse Electric & Mfg. Co.	119
Electric Welder	Portable	General Electric Co.	119
Field Coils	Aluminum	Economy Electric Devices Co.	*
Fitting	For conduit	Killark Electric Co.	94
Fuses	Indicating plug	A. L. Lewis Co.	94
Fuses	Cartridge renewable	Westinghouse Electric & Mfg. Co.	94
Fuses	Knife-blade renewable	Bussman Mfg. Co.	*
Fuses	Cartridge and plug	Southern Electric Co.	94
Fuses	Non-indicating	Johns-Pratt Co.	*
Fuses	Fiber plug	Trico Mfg. Co.	94
Fuses	Plug	General Electric Co.	94
Fuses	Fuse reducer	Plainville Electrical Products Co.	94
Fuses	Cutout base for	Bryant Electric Co.	94
Fuses	Puller and replacer	Fuse Puller Co.	94
Instruments	Insulation resistance tester	Westinghouse Electric & Mfg. Co.	102
Instruments	D.C. and A.C.	Westinghouse Electric & Mfg. Co.	102
Instruments	Foot-candle meter	Keuffel & Esser Co.	101
Insulators	Low voltage	R. Thomas & Sons Co.	94
Key	For pulleys	Smith & Serrell	103
Lamps	Mill type	Westinghouse company and Edison and National Lamp Works of G. E. Co.	102
Lamp Guard	Portable	Wm. N. Matthews & Bro.	101
Lightning Arresters	For industrial works	Westinghouse Electric & Mfg. Co.	102
Lightning Arresters	For industrial works	General Electric Co.	102
Motors	Synchronous	General Electric Co.	89
Motors	Induction	Louis Allis Co.	89
Motors	Induction	Electric Controller & Mfg. Co.	90
Motors	Induction	Wagner Electric & Mfg. Co.	90
Motors	Enclosed	American Electric Motors, Inc.	90
Motors	A.C. self-starting	Fidelity Electric Co.	90
Motors	Interchangeable frames	Master Electric Co.	90
Motors	Split-phase	Reynolds Electric Co.	90
Motors	Repulsion-start	Dayton Fan & Motor Co.	90
Motors	Fractional synchronous	France Mfg. Co.	90
Motor Starters	Across-the-line	Allen Bradley Co.	92
Motor Starters	Across-the-line	Industrial Controller Co.	92
Motor Starters	Resistance	Sundh Electric Co.	92
Motor Starters	Automatic	Sundh Electric Co.	92
Motor Starters	Safety	Union Electric Mfg. Co.	93
Motor Starters	Automatic	Cutler-Hammer Mfg. Co.	93
Pulleys	Paper composition	Composition Wood Products Co.	*
Repair Shop	Winding devices	P. E. Chapman Electrical Works.	95
Repair Shop	Commutator turner	George Bender	96
Repair Shop	Armature winder	T. F. Rhoades.	96
Repair Shop	Commutator grinder	Martindale Electric Co.	96
Repair Shop	Test bench	Paul G. Niehoff & Co.	97
Repair Shop	Solder pot	Westinghouse Electric & Mfg. Co.	97
Repair Shop	Heating furnace	Opal Electric & Mfg. Co.	97
Repair Shop	Heating furnace	Instantaneous Heater Co.	97
Repair Shop	Soldering iron	Rohne Electric Co.	97
Repair Shop	Blow torch	Armature Coil Equipment Co.	97
Repair Shop	Tool for turning, etc.	Triplex Machine Tool Corp.	97
Repair Shop	Fish wire	T. J. Cope.	97
Repair Shop	Adjustable cutter	Paul. W. Koch & Co.	96
Repair Shop	Pipe wrench	Greenfield Tap & Die Corp.	97
Rotary Converter	Martin	Northwestern Electric Co.	*
Signal Service	Watchman and fire alarm	Edwards & Co.	101
Signal Service	Bell-ringing transformer	Dongan Electric Co.	101
Switches	D.C. automatic reclosing	General Electric Co.	93
Switches	Mercury contact	Federal Gauge Co.	94
Switches	Remote thermostat	Minneapolis Heat Regulator Co.	94
Switches	Time signal	Stromberg Electric Co.	94
Switches	Safety across-the-line	Z & H Mfg. Co.	94
Switches	Safety across-the-line	Trumbull Electric & Mfg. Co.	93
Switches	Safety motor starting	Mutual Electric & Machine Co.	93
Switch	Shallow push button	Arrow Electric Co.	94
Switchbox	Shallow sectional	Chicago Fuse Mfg. Co.	94
Snap Switch	Cleat base indicating	Bryant Electric Co.	95
Steam Generator	Electrically heated	Electric Furnace Construction Co.	118
Steam Generator	Electrically heated	General Electric Co.	118
Tape	Seamless bias	Irvington Varnish & Insulator Co.	96

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small furnace 1 in. in diameter and 3½ in. deep, which will maintain a temperature of 1,500 deg. F., has been completed by the same company for heating small soldering irons and for special work.

In arc welding the demand for increased production and more rapid deposition of metal has caused the use of larger electrodes and higher current values. Values of 300 amp. and over are now used. A new constant-current welder has been built by the Westinghouse Electric & Manufacturing Company for this heavy work. A portable welding outfit driven by a gas engine has been developed by the same company. The General Electric Company has adapted the design of its automatic welding outfit to a portable semi-automatic welder.

Fuse Protection For Motors

(*Continued from page* 88)

operating temperature of these fuses referred to here. Tests were made on several fuses as shown in Table III. It was found that the temperature of the new fuses at rated current is about 20 deg. C. lower than that of the original fuses.

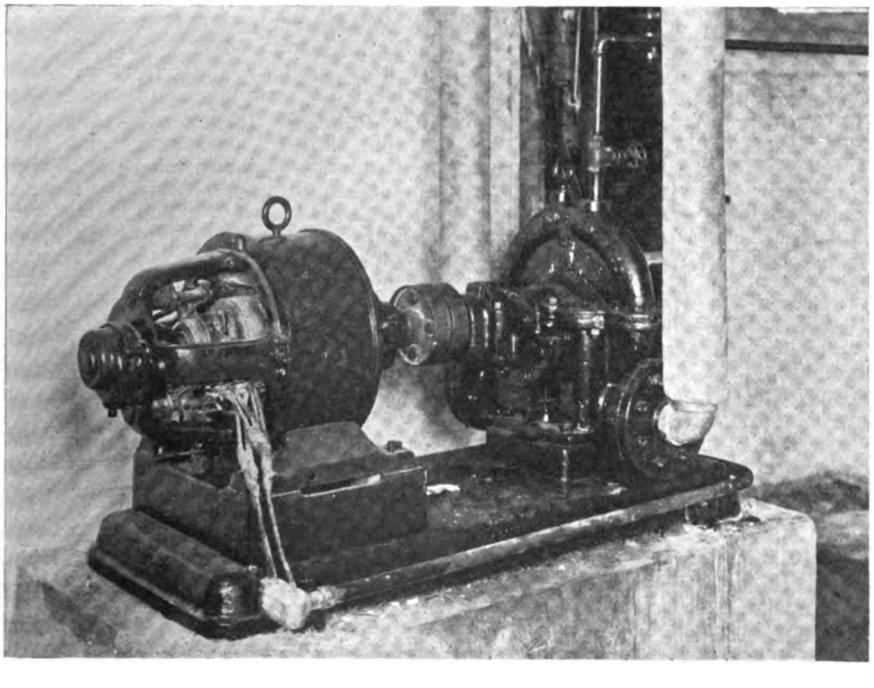
The heat loss in the 100-amp. time-lag fuse is 11 watts compared to 14.7 watts in the old fuse. These fuses were accordingly put into the clips. As a result the temperature in the panel case was so reduced that the covers could be replaced. The blowing of fuses ceased and no further trouble has been experienced with overheating.

Before these fuses were installed, the writer made many tests and experiments to determine how they acted under different strengths of current. Later he secured from the Electrical Testing Laboratories, New York, copies of tests made on various ratings of the fuse. It was found that the tests made by the writer and those of the Electrical Testing Laboratories agreed closely. The latter tests are those shown in Table III. As seen in this table, the temperature of the new fuses is appreciably less than that of the regular type with a zinc link. This is accounted for by the fact that the new fuse has a link composed principally of copper strip.

The inverse time lag, according to the manufacturer, the Multiple Electric Products Company, New York, is accomplished by the use of three other metals. These metals, cadmium, tin and antimony, are imposed on the copper strip in the form of a bead as shown in Fig. 5. It is explained that the beads remain unchanged while normal current is flowing through the fuse. At a current greater than 110 per cent of rating the four metals begin to fuse. This causes the formation of a new alloy as the three metals mix with the copper of the strip. This alloy produced at the beads has both a lower melting point and a higher resistance than copper has alone. Consequently there is a tendency to hasten the blowing of the fuse at the points where the alloying occurs. The melting point of the new alloy is so low that little heat is transmitted to the outer casing. The time required for this fusing gives the lag which makes the fuse of special value. It has also been the author's experience and it is stated by the manufacturer of the fuse that repeated overloads do not affect the operation of the fuse. In other words, if the overloads are not carried long enough to blow the fuse, it will act on the next overload like a new fuse.

Another fact that occurred to the writer is that these fuses with a copper element will help pay for themselves on account of their low resistance loss. For the 100-amp. and 200-amp. sizes, the loss in the copper link fuse is less than 70 per cent of the loss in zinc fuses of the same ratings. For the 60-amp. fuse it is 75 per cent and for the 30-amp. it is almost 90 per cent.

Fig. 5—Heavy current is required here to start a large column of water into motion.



Design of Telephone Instruments

BECAUSE it is generally so thoroughly understood that the Western Electric Company has been responsible for the greatest part of the development of telephone instruments, this fact was not mentioned in the historical frontispiece entitled "Design of Telephone Instruments" which was published in our December issue. For the benefit of those who are not familiar with the subject it should be pointed out that practically all of the developments mentioned in that frontispiece were made by men connected with the Western Electric Company and the Bell Telephone System. The only exception is in the case of the "carbon button" of Edison, which, soon after its invention, was given over to the Western Electric Company.

A Correction in Address

THIS opportunity is taken to rectify an error in the article entitled "Bonus on Operation and Maintenance" which began on page 4 of the January, 1923, issue of INDUSTRIAL ENGINEER. The address of The Federal Rubber Company was given as Racine, Wis., whereas the correct address is Cudahy, Wis.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

Russell Manufacturing Company, 814 Bath Avenue, Niagara Falls, N. Y.—This company is distributing a pocket memorandum book which contains some additional information on the trigger-lock reversible controller finger, its use and operation.

Homer Commutator Company, Cleveland, Ohio—A small folder describes the Homer replacement commutators which are built to replace those supplied on original equipments. These are furnished either: (a) Complete, ready to be placed on the armature shaft; (b) refilled, where the customer furnishes the shell, or (c) assembled, that is, copper bars and mica segments are assembled, machined and bound together by wire and the customer mounts them in his own shop.

The North American Manufacturing Company, 5902 Carnegie Avenue, Cleveland, Ohio—The North American gas and oil burning system is described in a small folder. With this system the gas or oil is discharged directly into a low-pressure blower which supplies the air for combustion and at the same time mixes with it the oil or gas.

A. F. Way Company, Inc., Hartford, Conn.—A small folder entitled "A Way for Drilling" gives a description of the various types of Way electric portable drills and bench stands.

The Sterling Varnish Company, Pittsburgh, Pa.—A 48-page booklet on Sterling insulating varnishes and compounds gives, under the headings of "Specifications" and "Uses," very complete and concise information on each of the varnishes manufactured by this company. The specifications include a description of the varnish, its base, solvent, specific gravity and baking time or drying period. In addition, directions are given for the care and use of varnishes, the preparation of material for varnish treatment, the application, baking, and subsequent treatment, discussions on the vacuum-pressure method of impregation and on methods of testing insulation.

Garland Manufacturing Company, West Pittsburgh, Pa.—This company is sending out a series of circulars describing its "Galvaduct" and "Loricated" — galvanized and enameled steel—conduits.

The Louis Allis Company, Milwaukee, Wis.—Bulletin 406 gives the distinguishing features of the type H. D. (heavy duty) L-A motor. Several new departures in design are incorporated in this motor. Probably the most pronounced is the special one-piece indestructible rotor winding which consists of a sheet of copper punched and formed by a special mechanical process and wrapped about the rotor core and soldered.

The Emerson Electric Manufacturing Company, St. Louis, Mo.—Bulletin No. 3,180 describes the Type IR repulsion-start, single-phase induction motor of 1/10 to 2 hp., with special provision for overload starting duty. Diagrams and specifications for each of the types and sizes, as well as the characteristics of this motor, are included.

Allis-Chalmers Manufacturing Company, Milwaukee, Wis.—Bulletin 140, entitled "Electrically Driven Saw Mills," contains a number of descriptions and illustrations of electrical installations in saw mills.

Sewickley Electric Manufacturing Company, Sewickley, Pa.—Bulletin 20 on the "Semco" watthour meter, Model I, gives the mechanical construction, adjustment, performance characteristics, capacities, connections and dimensions for the "Semco" single-phase watthour meter. Connections for checking meters are also shown.

Belden Manufacturing Company, 4625 West Van Buren Street, Chicago, Ill.—A 16-page booklet on "Beldenamel" magnet wire, entitled "Useful Hints for the Engineer and Purchasing Agent," describes the manufacture, methods of testing, uses, care in handling, winding, impregnating with varnish, care in baking, and a discussion on varnishes which are injurious to Beldenamel windings.

Brascolite Company, 2615-25 Washington Avenue, St. Louis, Mo.—Brascolite fixtures and reflectors for use in office and factory are described in a recent catalog. This fixture is of the semi-indirect type.

W. N. Best Furnace and Burner Corporation, 11 Broadway, New York City—"Calorex" liquid fuel equipments are described in a 48-page booklet, Furnace Catalog 36. This contains a number of descriptions of stationary and portable furnace equipments using oil or tar fuel. Considerable space is devoted to the description of the portable torches and furnaces which are used for brazing, preheating and welding in repair and other work, particularly in railroad shops and shipyards.

Reading Steel Casting Company, Inc., Bridgeport, Conn.—A small circular describes a new line of cast steel gate valves designed for 350 lb. working pressure, at a total temperature not exceeding 800 deg., or for 500 lb. working pressure at a total temperature below 100 deg.

Magnus Electric Company, Inc., 451 Greenwich Street, New York City—Recent literature describes a line of heavy-duty plugs and single and duplex flush receptacles which are especially adapted for use in maintenance departments of factories and repair shops.

Truscon Steel Company, Pressed Steel Department, Youngstown, Ohio—The various sizes and types, together with their advantages, of pressed steel platforms for use in connection with hand and power lift trucks are given in a small folder.

The C. O. Bartlett and Snow Company, Cleveland, Ohio—Bulletin 49 contains a number of photographs and diagrams of typical installations of mechanical sand-handling, continuous molding and mechanical carrying equipment taken from a number of iron and steel foundries. In nearly every case the equipment has been designed and installed in buildings already constructed. In these installations the labor involved in handling sand has been reduced to a minimum.

Brown Instrument Company, Philadelphia, Pa.—Catalog 85, entitled "Brown Automatic Control, Signaling and Alarm Instruments," devotes 24 pages to illustrations, diagrams and explanations of the Brown method of automatic control for heating furnaces. These instruments are made for low temperature control up to 1,000 deg. F. or high temperature control to 1,300 deg. F.

Whiting Corporation, Harvey, Ill.—Bulletin 159, entitled "Operation and Maintenance of Whiting Electric Cranes," devotes 32 pages to comments and illustrations on the different parts of each type of crane trolley and illustrates in detail the various parts which are most likely to wear out. This simplifies the work of the maintenance department in the ordering of repair parts. Special instructions for ordering repair parts are included.

The Battery Equipment and Supply Company, 1458 South Michigan Avenue, Chicago, Ill.—Catalog 5 devotes 16 pages to the description of, lists and prices of the complete line of "Besco" products for battery repair.

The Fuerst-Friedman Company, 1251 West Third Street, Cleveland, Ohio—Bulletin 25 lists the guaranteed rebuilt and new electric motors, generators, drills, compensators and other electrical equipment on hand.

The Canton Art Metal Company, Canton, Ohio—A 32-page catalog illustrates the special sheet-metal work such as tote boxes, chip pans, waste pans, tool cabinets, shop stands, gear guards, tanks, hoods, heating ducts, dust collectors, shelves, tool boxes, and other sheet metal work made by this company.

Burke Electric Company, Erie, Pa.—Bulletin 166 describes the type WA direct-current motors and generators. These motors and generators are made with rails and pulleys, with special belt-tightening sub-bases, and may be had with perforated enclosing covers, or full enclosed.

Mineral Oil Paint Company, Detroit, Mich.—A small folder describes the G. & B. mineral oil paint which, it is claimed, is an anti-corrosive, heat-resisting, acid-fume and damp-proof paint for bridges, viaducts, piping, structural iron and steel, concrete and metal or felt roofing of all kinds.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

March, 1923

McGraw-Hill Co., Inc. Chicago, Ill.



Accidentally Thrown Into Contact—*it could not have happened with a* BULL DOG

To be safe, a switch must be *Positive Quick Make* as well as *Quick Break*. Then the switch must be fully opened or fully closed and it cannot be accidentally operated. The play provided in the operating handle and the effort required to compress the *Quick Make* spring prevent unintentional operation.

The "Bull Dog" Safety Switch embodies the ten essential features for safety. It will meet your requirements for safety, operation and dependability.

Whenever you hear of an accident with a so-called "Safety Switch" check up on the "Bull Dog" features—type "A" switch parts—positive quick make and quick break—interlocks—ample wiring space—removable end plates—unit blade construction—standardized parts. It could not have happened with the "Bull Dog" on the job.

Send for catalog

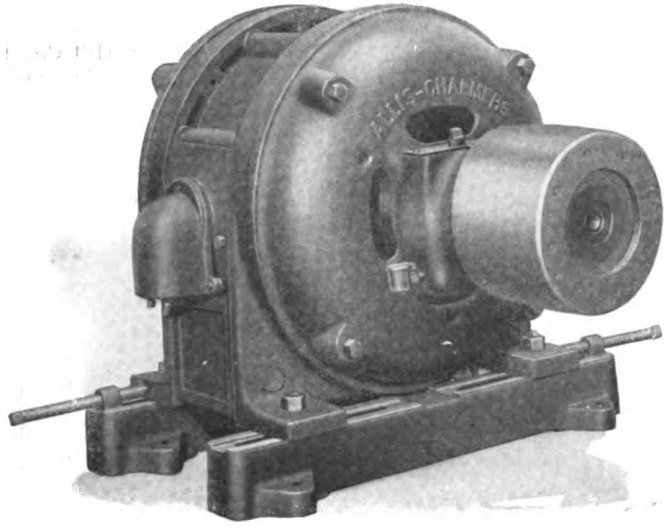
For Safety and Satisfaction Use the "Bull Dog"

The Bull Dog with Cabinet Open

BULL DOG
MUTUAL ELECTRIC & MACHINE CO.
DETROIT MICH. U.S.A.

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ALLIS-CHALMERS



Polyphase Induction Motors

Constant and Variable Speed

60 and 25 Cycle

For All Standard Speeds

Send for Bulletin

Type AR Squirrel Cage Motor

A new Motor of new design throughout, taking full advantage of all improvements and advances made during recent years.

Type "AR" motors are designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.

Method of ventilation is very effective resulting in even cooling and avoiding of "hot spots."

Bearings are of liberal design with spacious oil-wells.

Insulation is of highest grade, stator being treated with baked-on insulating varnish making the whole structure dust and moisture proof.

Motors are for floor or ceiling mounting being provided with very stiff and substantial rails.

Conduit terminal boxes are regular equipment.

PRODUCTS:

Electrical Machinery
Gas Engines
Steam Engines
Steam Turbines
Condensers
Oil Engines
Hydraulic Turbines
Pumping Engines
Centrifugal Pumps
Mining Machinery
Metallurgical Machinery
Crushing Machinery
Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
Air Compressors
Air Brakes
Steam and Electric Hoists
Farm Tractors
Power Transmission Machinery

ALLIS-CHALMERS MANUFACTURING COMPANY

Milwaukee, Wisconsin

District Offices in All Principal Cities

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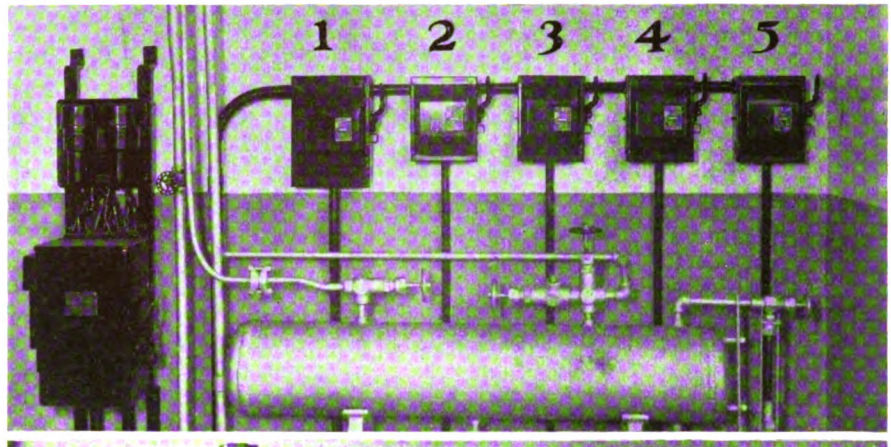
INDUSTRIAL ENGINEER

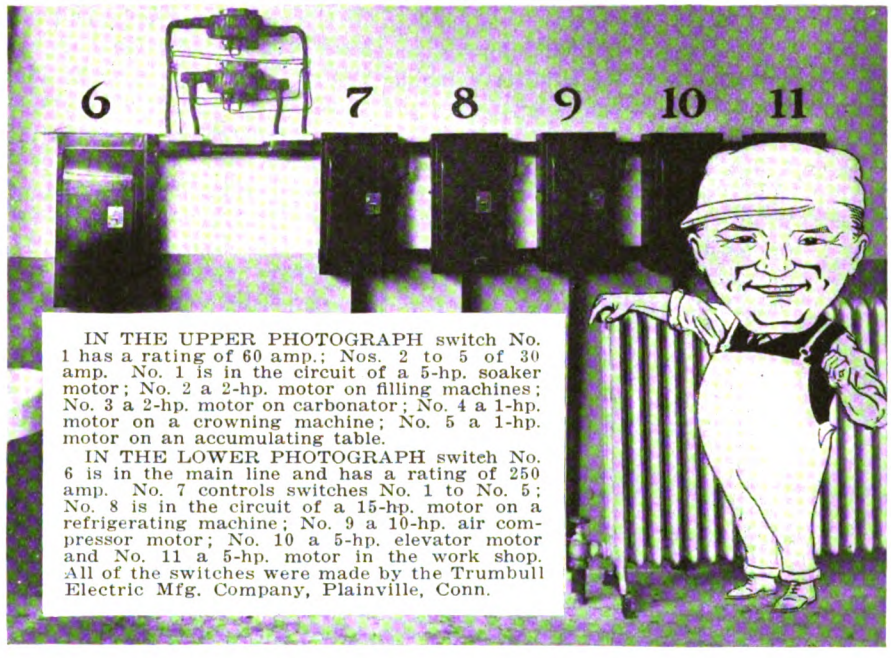
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, March, 1923 *Number 3*

Two Good Clean-Cut Installations

That Show Work of the Head as well as the Hand From Operating and Safety Standpoints.





IN THE UPPER PHOTOGRAPH switch No. 1 has a rating of 60 amp.; Nos. 2 to 5 of 30 amp. No. 1 is in the circuit of a 5-hp. soaker motor; No. 2 a 2-hp. motor on filling machines; No. 3 a 2-hp. motor on carbonator; No. 4 a 1-hp. motor on a crowning machine; No. 5 a 1-hp. motor on an accumulating table.

IN THE LOWER PHOTOGRAPH switch No. 6 is in the main line and has a rating of 250 amp. No. 7 controls switches No. 1 to No. 5; No. 8 is in the circuit of a 15-hp. motor on a refrigerating machine; No. 9 a 10-hp. air compressor motor; No. 10 a 5-hp. elevator motor and No. 11 a 5-hp. motor in the work shop. All of the switches were made by the Trumbull Electric Mfg. Company, Plainville, Conn.

WHILE looking through the pages of a manufacturer's house organ that I regularly read because of its homely philosophy and down-to-earth discussions on business and things in general, I spied two photographs that showed work of the head as well as the hand. Two things got my interest: First the general character of the installation and second, the fact that I had been in the plant and had either missed something or these installations had been made since the time I was there. So I wrote to my good friend of the Coca Cola Bottling Company of Greenville, S. C., and asked him a few questions about these two installations and the photographs I had seen. He came back with a nice letter and sent the two photographs that are shown here.

In the caption under the pictures as they appeared in the house organ was this statement: "Greenville installations are safe under the guardianship of Mr. J. J. McDevitt, Electrical Inspector." Naturally, I was interested to know why Greenville installations are any safer under Mr. McDevitt's guardianship than others elsewhere under the guardianship of other men good and true—and I found out through the P. S. my good friend added to his letter which read as follows: "We had two reasons for this installation. First, we wanted the best, and second, our city laws require safety switches and all wires run in conduit." And then I got the point of Mr. McDevitt's guardianship but it seems to me that this is a left-handed compliment to Mr. McDevitt for under conditions where the plant operator wants the best and gets it, the work of the electrical inspector is not so much that of a guardian as it is of an endorser of things as they should be without the trouble of exercising his authority to force that situation.

There was a time when rules of National Electrical Code and municipal ordinances based upon it were sometimes wilfully evaded but these instances and the heated arguments which they called forth are comparatively rare now, mainly because standards of construction in industrial plants have greatly improved and the men in these plants realize that a good installation that will pass all inspections from the standpoints of service requirements, safety to workmen and fire hazards are the cheapest installations in the long run. We should, therefore, congratulate the men in the plants for this kind of thinking when it is displayed in their work rather than call attention to the fact that they are getting by the inspector who looks the job over mainly from its proof against fire hazards, on which an insurance policy covering the plant is written, or to see that it follows the letter of a city ordinance that deals with every installation as though they were exactly alike with little or no regard for the service requirements of different jobs.

Unless we are willing to give credit where credit is due we often find ourselves in the position of Abe Potash of Potash and Perlmutter combination when he said, "Work all your life to get somewhere and when you get there—where are you?"

The installations shown here any one might be proud of and I want to congratulate everyone who had anything to do with them.

Practical Pete

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A Glimpse Into the

Works of Pillsbury Flour Mills Company

An organization which has taken an important part in the development of the greatest flour milling center in the world. This is the third of a series devoted to the growth and extent of basic American industries.

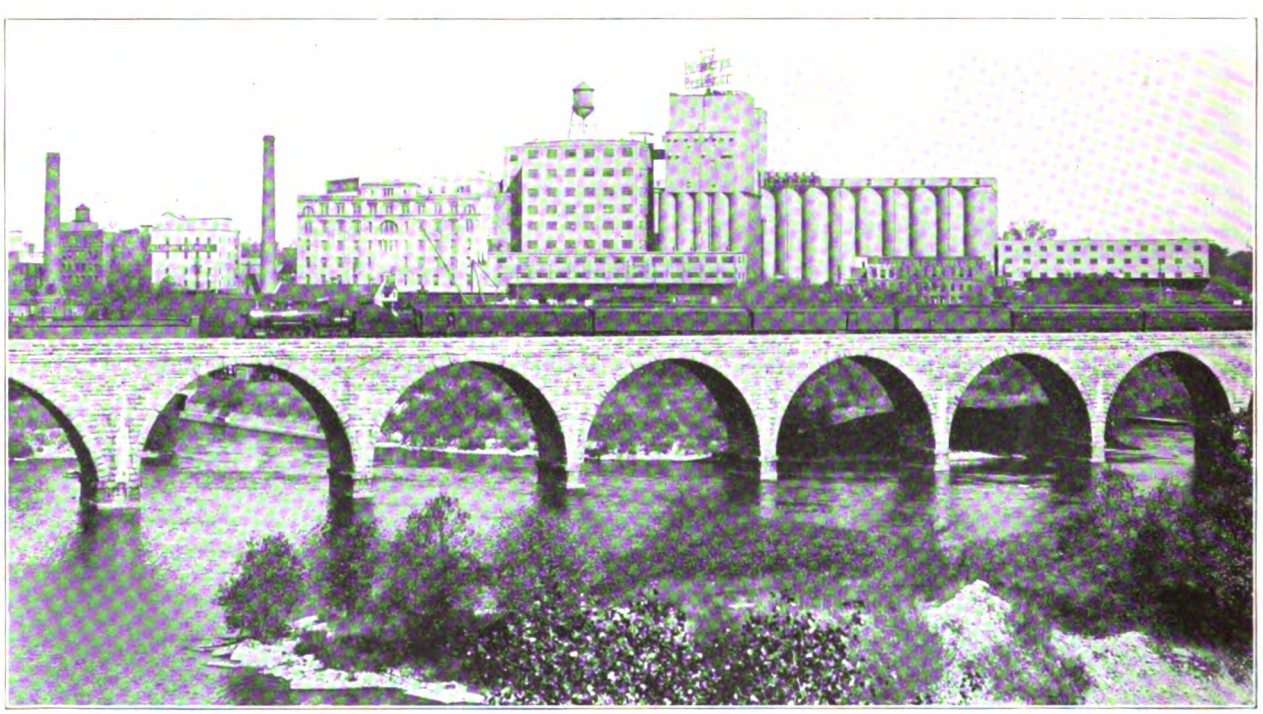
SEVERAL flour mills grouped around St. Anthony Falls at Minneapolis, Minn., are capable of producing 90,000 bbl. of flour per day. Of these the largest is the Pillsbury "A" mill with a daily capacity of 17,500 bbl. This concentration of an industry is largely due to location, water power, transportation and other economic reasons. Buffalo, N. Y., the second largest flour milling city, also owes its growth to similar reasons.

From the earliest period of history, wheat has formed one of the basic foods of the world. With the development of the Northwest as a wheat-growing section came a concentration and development of large milling centers. Because a large proportion of this wheat must pass through Minneapolis, where St. Anthony Falls offered opportunities for the utilization of water power, there was established there the largest group of flour mills in the world, of which the Pillsbury group is an important part.

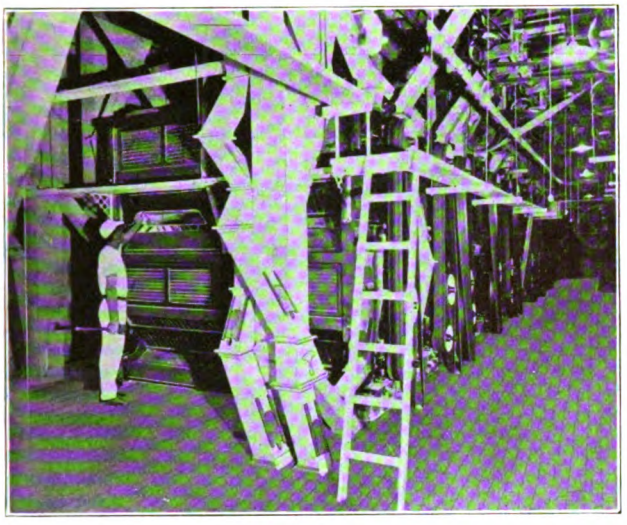
The advantages of this location were recognized early, as records show the first mill was erected here in 1822 by the Federal Government. The first commercial mill was built in 1854. By 1866 eight mills were operating at the Falls with a yearly production of 172,000 bbl. of flour. In that same year the first of what later became one of the Pillsbury group of mills was erected. It was about this time that the advantage of the invention of the McCormick reaper and self-binder, as described on these pages in the February issue of INDUSTRIAL ENGINEER, was felt. In addition, increased transportation facilities, the entrance of the United States into the commerce of the world as an exporter of flour, and the invention of the middlings purifier, as well as the change from millstones to rolls in the milling process, have all contributed to making Minneapolis milling history. The growth was rapid; in 1876 the Minneapolis mills produced 1,000,000 bbl. of flour and had doubled this pro-

This largest flour mill in the world, with its daily capacity of 17,500 bbl., only equals the demand of New York and Philadelphia.

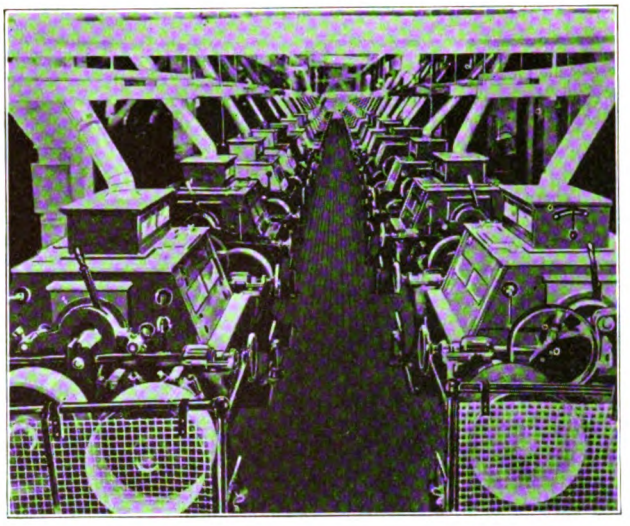
This largest unit of the Pillsbury group of mills in Minneapolis began in 1881 with the construction of the unit marked here with "A" with a capacity of 5,000 bbl. per day. The large circular tanks at the right are tile elevators with a storage capacity of 4,750,000 bu. A problem of the industry is that wheat is harvested and a large percentage of it marketed within a period of a few months; in contrast, the milling process is continuous. This mill is operated by a 2,000-hp. water turbine but has an auxiliary steam plant to maintain production in times of a water shortage. Some idea of the amount of work involved in the manufacture of flour may be gained from the fact that 19 reductions or grindings are accomplished in the breakers and rolls all located on the first floor and 180 separations, which separate the stock into middlings, bran, flour and screenings, take place on the fourth, fifth and sixth floors. The third floor is devoted to packing.



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Attaching a new silk bolting cloth in the revolving cylinder of a reel. These machines operate with a shaking motion and separate the stock into middlings, bran, flour and screenings.

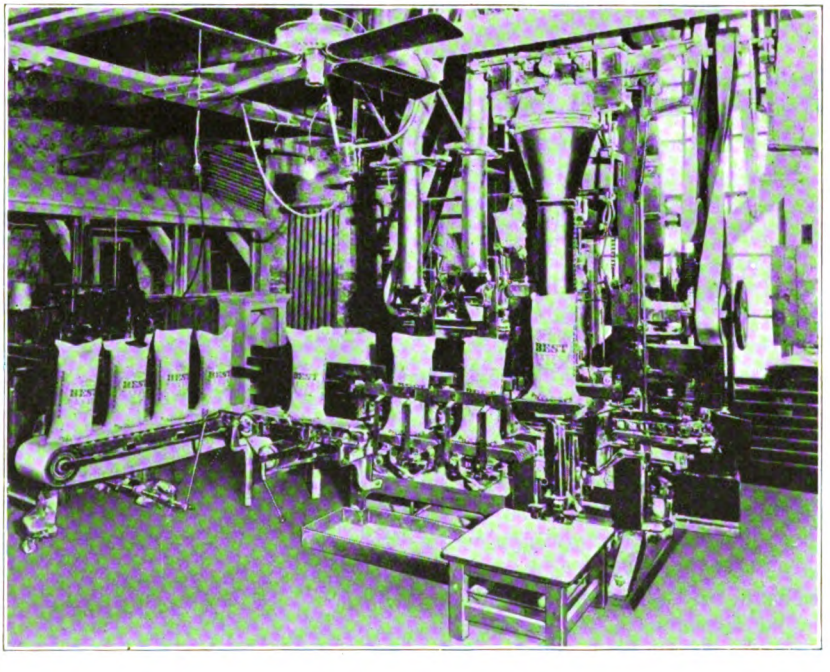


One of several rows of grinding machines in the Pillsbury "A" mill. There are 250 of these on one floor.

duction in 1880. By 1920 the total output of the Minneapolis mills was 16,883,000 bbl. of flour. It requires approximately 5 bu. of wheat to produce a barrel of flour which will make from 240 to 300 pound-loaves of bread. Government records show an average consumption of about 5 bu. of wheat per capita in the United States.

A part of the development of Minneapolis as a flour milling industry was the erection of what is known as the Pillsbury "A" mill in 1881, which was originally built with a daily capacity of 5,000 bbl. This building, identified here with the letter "A" on the front, is still a part of the Pillsbury "A" mill, the largest individual mill in the world with a daily capacity of 17,500 bbl. of flour, or 87,500 bu. of wheat. Large as this is, it is barely equal to the requirements of the cities of Greater New York and Philadelphia in their daily flour ration.

This mill is operated by a 2,000-hp. water turbine getting its supply from St. Anthony Falls. This turbine is placed about 50 ft. below the basement of the mill and is connected to the main line shafts by an endless hemp rope about 7,000 ft. in length. Belts, in turn, distribute the power to the various mills through the building. Because it is desirable to place the heaviest milling machinery on the first floor where it is near the line-shaft, the milling process begins on the first floor and the milled wheat progresses upward as it is operated on. It is a common practice in many other industrial processes to begin at the top of the building and allow the material to flow down by gravity as it is operated on. A particular feature is the large number of operations involved in the manufacture of flour. Aside from the cleaning, screening and washing of the wheat, which are done before reaching the mills, the wheat passes through 19 reductions or grindings in the breakers and rolls and 180 separations to remove the bran coat to produce white flour. It requires about an hour for the wheat to complete the manufacturing processes.



A giant flour packing machine which automatically fills, weighs and sews the sacks of "Pillsbury's Best." Four 49-lb. sacks make a barrel of flour.

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The bench at the right is used for light work and is equipped with vises and an electric drill. At the left is the bench for armature winding and heavy work.

Some Practical Details of a Large

Industrial Plant Repair Shop

Together With the Methods of Handling Inspection and Repair Work in the Various Departments

By E. J. FORD

Chief Electrician, Kewanee Plant, Walworth Manufacturing Co., Kewanee, Ill.

PRESENT methods of handling maintenance and repair work on electrical equipment in the Kewanee Plant, Walworth Manufacturing Company, Kewanee, Ill., are based on twenty years of experience and study in solving the problems involved therein and determining the procedure best suited to our conditions. The repair shop has lately been moved into larger quarters and new equipment installed; so that, with certain recent changes in the routine, we feel that we are in better position than ever to handle the job of keeping in proper operating condition the equipment which comes under the control of the electrical department. There is no intention to imply that our routine and methods cannot be improved, but experience has shown that under present conditions they accomplish their purpose satisfactorily.

A SYSTEMATIC schedule of inspection to detect motor and control trouble as soon as it develops and a well-equipped repair shop for handling the unavoidable breakdowns, mean low operating costs and minimum loss of production through failure of power service. In this article details are given of the methods employed and the facilities available for the maintenance of electrical equipment in the 29 departments, representing over 18 acres of floor space, in a plant which covers 36 acres of ground. Although 90 of 238 motors are exposed to dust and steam and acid fumes the care which they receive is so effective that not more than 15 motors are rewound a year.

The product of this plant is principally fittings, valves, pipe bends and drivewell points. For producing these articles there are in operation four foundries, steel, malleable and grey iron, and brass, a hot galvanizing plant, several machine shops, pattern shop, core rooms, and so on, involving twenty-nine departments in a plant covering thirty-six acres. All of the machines in these departments are motor driven, either individually or in groups. There are now installed 238 motors, with a total connected load of 3700 hp. Of these motors 219 are direct-current machines operating at 240 volts and representing 2700 hp. while there are 19 three-phase, 440-volt, 25-cycle squirrel cage induction motors carrying a load of approximately 1000 hp., one-third of the total power load

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Motor and crane inspectors' report sheets.

All motors and cranes are inspected daily, but a written report is not required unless trouble is found. In this event the inspector describes the nature of the repairs needed and gives the report to the chief electrician, who notes on it any comments or directions necessary and orders the work done.

WALWORTH MFG. COMPANY.

MOTOR INSPECTION REPORT DATE:- Nov-3-22

NOTES OF REPAIRS NECESSARY:-

Motor No 8020 - Burnt to ground on front Vee ring, burnt off the end of two bars in two different places

REPAIRS MADE:

Motor No 8020: Repair man cleared ground on Vee ring. removed ground connection to frame Temporary repair only NOTE Commutator will need repairing (Mell removed armature & sent him commutator to replace E.J.F.

R. Felt
Inspector.

WALWORTH MFG. COMPANY.

CRANE INSPECTION REPORT Date:- Jan 3-23

(1) Steel Fdy crane needs new Brushes on bridge controller
(2) East yard crane needs 2 crane trolley wheels

REPAIRS MADE: Boiler House coal crane reset tension on hoist controller fingers. Put one new segment on pipe Fabricating crane bridge cont

Wm. De Berre
Inspector

of the plant. The motors range in size from 1/40 hp. to 175 hp.; the majority is however, under 75 hp. and of the total number of motors 103 are rated under 5 hp.

Approximately one-half of the motors, 120, are connected directly, or through gearing to the machines which they drive; belt drive is employed with 115 motors, and chain drive with three.

In addition to the motors mentioned above there are ten traveling cranes, two small, narrow-gage electric locomotives and three industrial tractors.

The indoor lighting systems comprise a total of 3,800 Mazda lamps ranging from 50 to 500 watts, arranged for the most part for localized-general illumination. For yard lighting fifteen 1000-watt lamps are employed. The total lighting load amounts to 270 kw.

A staff of ten men, comprising one armature winder, one helper (who also acts as crane inspector), two motor inspectors, one night troubleman, two wiremen and two helpers and one lamp washer, is required in the electrical department to handle the inspection, repair and new construction work.

All Motors Are Inspected Once a Day

Failure of a motor may shut down an important machine or group of machines, causing a serious loss of production. Also, the prompt detection of trouble will often save expensive trips to the repair shop, and so a thorough-going inspection routine is in force. Two motor inspectors make a careful examination of every motor and its control equipment once a day. This inspection involves examination of bearings and field coils to detect undue heating, determining whether there is sufficient oil in the bearings, detection of brush or commutator trouble, examination of contact surfaces of switches and starters, and so on. Motors which are located in very dirty places, for example in the foundries, are blown out daily with compressed air, at a pressure of 35 lbs. per sq. in. All other motors are blown out once a month.

In like manner the oil in the bearings of motors in the foundries and other unusually dirty places is changed once a week. On the whole, the oil in the bearings of the other motors is changed when it begins to show dark.

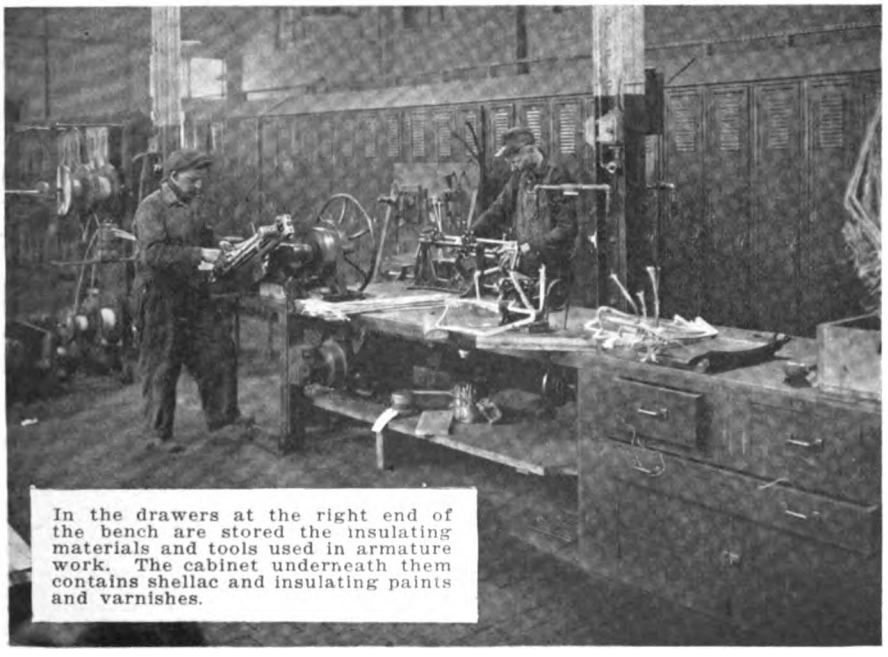
Another inspector is assigned to make a daily inspection of the cranes. He examines the motors, bearings, controller, driving pinions and shafts and so forth. Once a week he sounds the truck wheels with a hammer, to see if any of them are cracked.

As a check, the chief electrician inspects each motor once a week and the cranes once in two weeks.

When examination shows that a motor or crane is in proper condition no report is made. If any trouble is discovered, however, the inspector fills out a *Crane Inspection Report* or *Motor Inspection Report*, as the case may be, describing the nature of the trouble and turns it over to the chief electrician. These report forms are shown in an accompanying illustration. The latter then marks on the report any com-

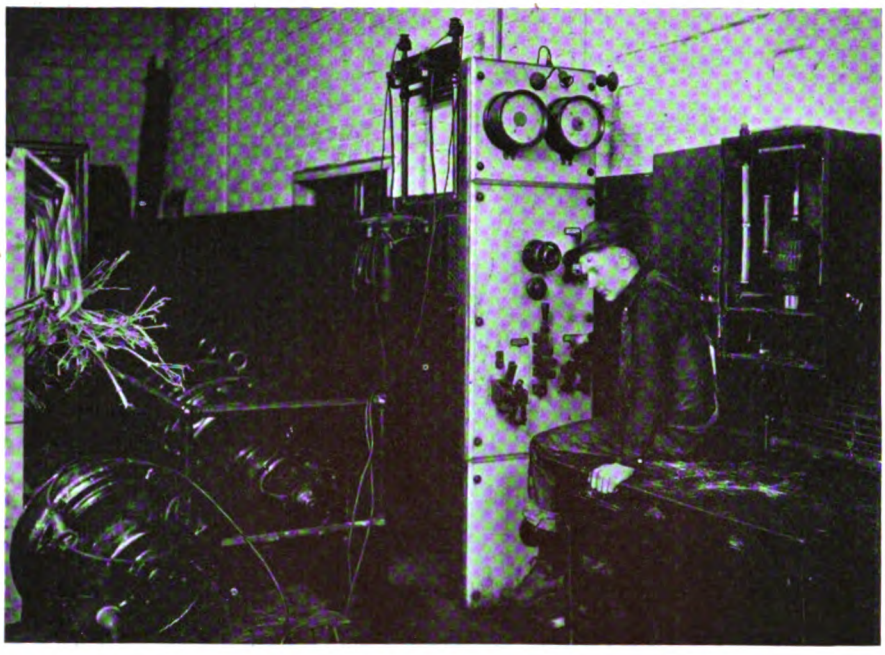
Armature coils are wound and pulled on this bench.

The equipment comprises a Segur coil winding machine, Segur taping machine, an Armature Equipment Co. spreader, and an insulation cutter, seen at the right. The coil winder and taping machines are driven by individual motors mounted under the bench. The reel rack can be seen at the left side of the illustration. The electrical supply store room is on the other side of the row of steel lockers, which are placed in approximately the center of the building, and enclose the repair shop on one side.



In the drawers at the right end of the bench are stored the insulating materials and tools used in armature work. The cabinet underneath them contains shellac and insulating paints and varnishes.

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This is the high-voltage testing outfit and its control board.

The outfit consists of a 25-hp. 240-volt d.c. motor direct-connected to a 15-kva, 220-volt, 60-cycle, three phase a.c. generator, connected single-phase to the switchboard with a 1.25-kw. 125-volt exciter, and a 7-kw. transformer with a ratio of 10 to 1. From this switchboard there can be obtained 5 to 125 volts and 250 volts d.c., 5 to 220 volts, 60-cycle, 3-phase a.c. and 5 to 3000 volts, 60-cycle, single-phase, a.c. An electrically heated oven for baking small armatures is shown on the wall to the right.

ments or notes which he considers necessary and gives orders to have the work done. If it is desired to find the exact cost of a repair or installation job, or if one of the other departments requests that certain work be done, the superintendent of maintenance issues in triplicate a *Service Order* bearing a serial number, prefixed by the letter (*R*).

If the job is estimated to exceed a certain amount, the *Service Order* is issued by the works engineer and bears a number prefixed by the letter (*M*), for *Minor Appropriation*, approved by the general superintendent and the superintendent of maintenance.

The *Service Order* is then sent to the chief electrician, who renders the service called for. All *Job Time Cards* and *Stores Issue Cards* made out for the work in question must bear the letter and number of the *Service Order* authorizing the work.

If the *Electrical Department* finds it necessary to call on other departments, for example, having a commutator turned in the machine shop, for work in connection with the job, the order issued by the *Electrical Department* bears the number assigned to the original order. When the job is completed the order is marked O. K. by the chief electrician and returned to the superintendent of maintenance. The date on which the work was completed is marked on the file copy of the order and the original sent to the *Cost Department*, where the total cost of the work is charged against the department for which it was done.

Failure of motors and control equipment can hardly be eliminated altogether, but we have found that a careful inspection daily will reduce breakdowns, with their attendant loss of time and production, to a minimum.

The lighting system is also given the care necessary to keep it in good condition. Burned-out and blackened bulbs are replaced as soon as discovered and every lamp and reflector in the plant is washed once a month with soap and water.

Arrangement of Equipment in Repair Shop

The electrical repair shop proper occupies a space of 38 ft. by 26 ft. in one end of a building which was formerly used by one of the manufacturing departments, but has now been turned over to the electrical and steam fitting departments. As will be seen from the accompanying illustrations, there are two benches, one for light and the other for heavy work, along the outside wall, where full advantage can be taken of the daylight. These benches are 14 ft. long and 3 ft. wide; one, used for heavy work is 2½ ft. high, while the other is 3 ft. They are equipped with drawers 20 in. wide and 10 in. deep, which are assigned to the various members of the electrical depart-

SERVICE ORDER

Kuvanee WORKS

January 6th. 192 3

TO Electrical Repair DEPT.

PLEASE FURNISH FOR Tapping DEPT.

DELIVER TO 1st. floor F.F. Building.

Rewind armature and make other necessary repairs on 75-H.P. Motor No. 8020 in Tapping Dept.

DATE REQUIRED February 19-3.

APPROVED

SIGNED Engg. Dept.

BY REF

DIRECT CHARGE M-3255 ORDER NO.

All orders for Repairs, Replacement, Tools, Training and all Inter-Department Service must be made on this form; orders on Store Department excepted.

SERVICE ORDER

Kuvanee WORKS

Jan. 16 192 3

To Machine Repair DEPT.

PLEASE FURNISH FOR Electrical Repair DEPT.

DELIVER TO

Please turn commutator on 75 HP armature motor No 8020 Tapping Dept

DATE REQUIRED At once

APPROVED

SIGNED E.J. Ford

BY

DIRECT CHARGE M-3255 ORDER NO.

All orders for Repairs, Replacements, Tools, Training and all Inter-Department Service must be made on this form; orders on Store Department excepted.

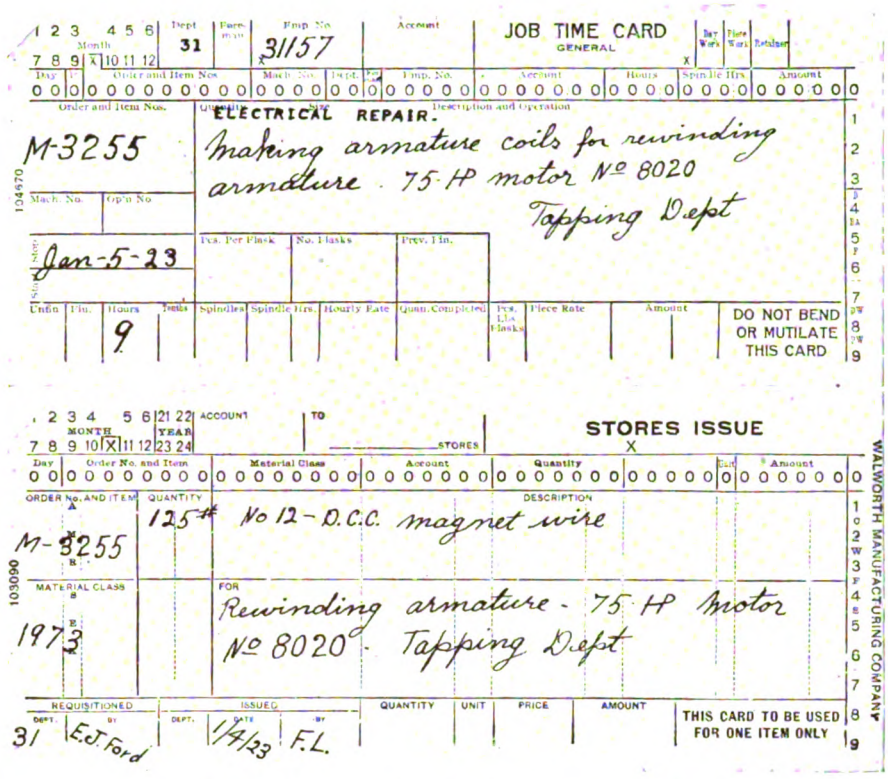
All requests for service rendered by one department for another are made on this form.

The order on the left was issued by the *Engineering Department* to cover repairs necessary on a large motor in the *Tapping Department*. This order is issued in triplicate; the original goes to the department which will do the work, while one copy is filed in the department originating the order and the third in the office of superintendent of maintenance. The letter M prefixed to the number of the order (3255) shows that a *Minor Appropriation* has been made to cover the cost of the work. *Job Time Cards*, *Stores Issue Cards* and other *Service Orders* for work on this job must bear the number (M-3255) of the original order.

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These cards record the time and material spent on a job.

On the *Job Time Card* (at top of illustration) the repairman puts down each day the time spent on the job and charges it against the number of the *Service Order*, M-3255 in this case. The material required for the job is drawn from the storeroom on the *Stores Issue Card*, which also bears the number, M-3255, of the *Service Order*. These cards are sent to the office daily until the job is completed. Then the total cost is figured in the Cost Department and entered under the order numbers.



ment. Each drawer is provided with a hasp and staple so that it can be locked with a padlock.

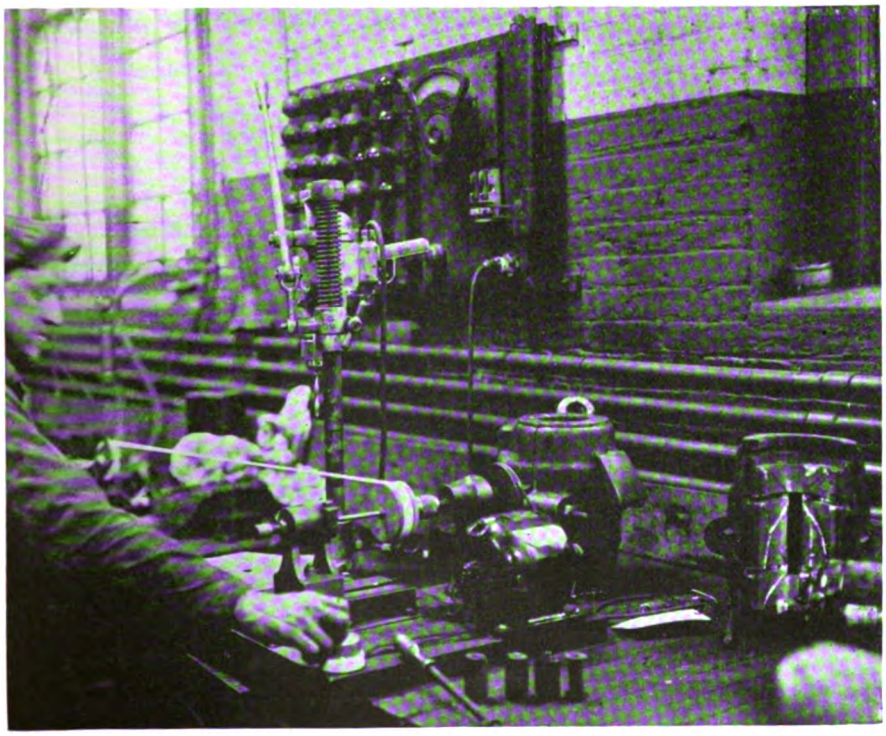
The benches are fitted with vises and a Black and Decker electric drill supported by a bench stand is mounted on one end of the bench used for light work. The other bench, which is used mostly by the armature winders, has on it a small gas furnace, for heating soldering irons and so on.

On the wall, above this bench, is a bank of twenty lamps used for testing purposes. By means of six switches any number of lamps from one to twenty can be thrown into circuit. An ammeter, mounted beside the lamps on the same board, indicates the amount of current flowing.

The test leads are run through ½-in. conduit which goes up for a distance of 14 ft. above the bench and is then bent at a right angle, to bring the end over the outer edge of the bench. A small pulley is suspended from the upper end of the conduit. The test leads, which are 30 ft. long, pass over this pulley and by means of a counterweight are drawn up and out of the way when not in use.

At one end of the shop is located a high-voltage testing outfit comprising a 25-hp., 240-volt d.c. motor direct-connected to a 15-kva., 220-volt, 60-cycle, three-phase a.c. generator with a 1.25-kw., 125-volt d.c. exciter, and a 7-kw. transformer, ratio 10:1. The generator is connected single-phase to, and controlled by, a switchboard provided with the necessary switches, circuit breaker and voltmeter and ammeter. High-tension test leads are brought out from the back of the board. This outfit can be used for making a wide variety of tests, inasmuch as it is possible to obtain from 5 to 125 volts and 250 volts direct current; from 5 to 220 volts, 60 cycles, 3-phase and from 5 to 3,000 volts, 60 cycles, single-phase.

A row of double steel lockers running down approximately the center of the building forms the opposite side of the shop and serves to cut it off from the rest of the building. A 14-ft. bench placed several feet away from and in front of these lockers contains the coil-making equipment. This consists of a Segur coil winder, a Segur taping machine, an Armature Equipment Co. coil spreader and an insulation cutter. The coil winder and taping machine are driven by motors mounted under the bench. One large and two small drawers at one end of the bench are used for storing the fishpaper, empire cloth and other insulating materials, and the drifts and other tools employed in armature work. A closed cabinet be-



Machine for winding magnets and small coils.

This device was made in the repair shop and consists of a spindle threaded at one end to take a small drill chuck and mounted in an old sewing machine head. The spindle is driven by a ⅛-hp. motor. When winding magnet coils, a headless screw is run into the core and then firmly gripped by the chuck. As shown here the machine is winding tape on small spools, for use in the coil tapping machine, in much less time than could be done by hand.

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Minimum Stock Requirements for Wiring Equipment and Supplies

THIS LIST covers the kind and minimum amount of materials and parts kept in stock for maintenance, repairs and new construction in the twenty-nine departments of the Walworth Manufacturing Company, Kewanee, Ill.

WIRE AND WIRING EQUIPMENT

I—Wire	Minimum Stock
Rubber covered, stranded Nos. 0000 and 00	100 ft. each
Rubber covered, stranded Nos. 1, 2, 4, 6.	100 ft. each
Rubber covered, solid, Nos. 8, 10	250 ft. each
Rubber covered, No. 12	500 ft.
Rubber covered, No. 14	1000 ft.
Weather proof, 500,000 circ. mil	100 ft.
Magnet, d.c.c., Nos. 22, 24, 25	5 lb. each
Magnet, d.s.c., Nos. 26, 27, 28, 29, 31, 32, 33, 35, 36	3 lb. each
Magnet, for armature and field coils—	
d.c.c., Nos. 9, 18	100 lb. each
d.c.c., No. 10	175 lb.
d.c.c., No. 12	75 lb.
d.c.c., No. 14	10 lb.
d.c.c., No. 15	50 lb.
d.c.c., No. 17	75 lb.
d.c.c., No. 20	20 lb.
Single Cotton, enameled, Nos. 23, 27	10 lb.
Trolley, hand drawn bare, Nos. 00, 1, 4, 6	100 ft. each
Soft drawn bare copper, No. 00 (other sizes for other depts.)	25 ft.
Twin conductor—	
No. 18, super service flexible	50 ft.
No. 18, packing house cord	100 ft.
No. 18, drop cord	25 ft.
Annunciator cable, 6 wire	60 ft.
II—Wiring Equipment	
Wire connectors, Nos. 200, 201, 202, 203, 205	2 each
Steel armored conductor, flexible twin, No. 14	25 ft.
Malleable brackets	6
Wood brackets	6
Soldering lugs, 30, 60, 100 and 200-amp.	5 each
Cross arms, 2-pin, 4-pin, 6-pin	2 each
Cross arm pins, 1½ in. x 9 in. locust, corner	12
Cross arm pins, 1½ in. x 9 in. locust, straight line	12
Channel pins, ¾ in. No. 00 wire	10
Cable clamps, Matthews	6
Cross arm braces	6
Lightning arresters, type MP	3
Lightning arresters, type C	3
Flexible steel conduit, ¾ in., 1 in., 1¼ in.	10 ft. each
Comb. couplings for d.s. conduit, ¾ in., 1 in., 1¼ in	4 each
Panel box connectors for d.s. conduit, ¾ in., 1 in., 1¼ in	2 each
Elasticaps, No. 210	100

LIGHTING EQUIPMENT

III—Lamps	Minimum Stock
Mill type, 50-watt, 220 and 230-volt	50 each
Mazda C, 230-volt, 100, 200, 300 and 500-watt	10 each
Mazda C, 230-volt, 1000-watt	5
Mazda C, 230-volt, 500-watt	3
Headlight, 94-watt, 110-volt	2
IV—Mercury Lamp Repairs	
Clamp screws, No. 711	6
Shifter resistance for type P, lamps Nos. 1, 4, 5	2 each
Shifters for type P, lamp, old and new	2 each
V—Reflectors and Sockets (George Cutter Co.)	
200-watt RLM, dome	5
200-watt RLM, holder socket	5
200-watt RLM, hook	5
100-watt RLM	5
50-watt RLM	10
Holders for same	10
Porcelain floodlight sockets	2
Mica sockets	20
Edison base receptacles—porcelain	5
Attachment plugs, Hubbel	10
Attachment caps, Hubbel	10
Guards for mica sockets	5
Inner globe for blue-print machine	2

CONDUIT FITTINGS

VI—Conduit Bushings	
½ in., ¾ in., 1 in	10 each
1¼ in.	5
1½ in., 2 in	3 each
VII—Locknuts	
½ in.	10
¾ in., 1 in	5 each
1¼ in., 1½ in., 2 in	3 each
VIII—Hangers	
Efficiency	12
IX—Clamps	
I-Beam, ½ in.	25
X—Outlet Insulators	
½ in., ¾ in., 1 in., 1¼ in	5 each
Outlet boxes	5

XI—Condulets (Crouse-Hinds)—Minimum stock of each in parenthesis:

A-13-	(10)	B -(3)	E-13	(5)	FE-13	(1)	LB-1100	(10)
A-22-	(3)	B -(3)	E-23	(2)	FE-23	(1)	LB-2200	(10)
A-32-	(3)	B -(3)	E-33	(2)	FE-33	(1)	LB-3300	(5)
A-43-	(2)	BE-(2)	E-43	(2)	FE-43	(1)	LB-4400	(5)
A-53-	(2)	BE-(2)	E-53	(2)	FE-53	(1)	LB-5500	(5)
A-63-	(2)	BE-(2)	E-63	(2)	FE-63	(1)	LB-6600	(3)

LR-1100	(5)	T-11100	(10)	X-111100	(2)	G-1101	(2)
LR-2200	(5)	T-22200	(10)	X-222200	(2)	GL-1101	(2)
LR-3300	(5)	T-33300	(5)	X-311300	(2)	GS-1108	(2)
LL-4400	(5)	T-44400	(3)			GSL-1108	(2)
LL-5500	(5)	T-55500	(1)			H-110	(2)
LL-6600	(5)	T-66600	(1)			JRG-1	(3)

C-1100	(3)	UN-11	(2)	V-8	(2)
C-2200	(3)	UN-22	(2)	V-9	(2)
UB-55	(2)			YC-11302	(3)
UB-66	(2)			Z-2302	(3)
				ZU-121302	(1)

SWITCHES AND FUSES

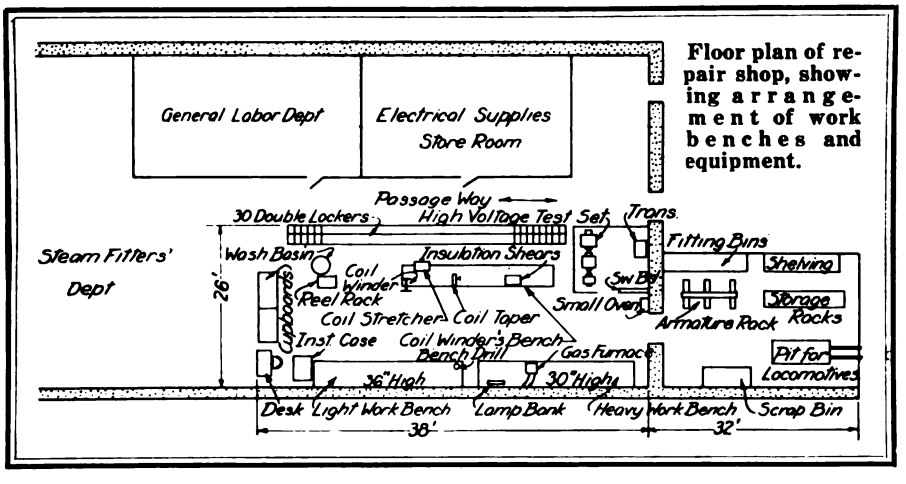
XII—Switches	
Ceiling switches, 5-amp., 250-volt, single pole	5
Nickel snap, 5-amp., 250-volt, single-pole, open-base, wing turn, indicating	5
Nickel snap, 5-amp., 250-volt, 3-way, open-base, wing turn, indicating	2
Knife, Crouse-Hinds, single-throw, front-connected, 250-volt, double-pole, fusible, 30, 60, 100-amp	1 each
Knife, Crouse-Hinds, single-throw, double-pole, non-fusible, 100, 200, 400-amp.	1 each
Knife, Crouse-Hinds, single-throw, single-pole, non-fusible, 30, 60, 100, 200, 400-amp.	1 each
Safety enclosed, Crouse-Hinds, 30-amp., 250-volt, double-pole	1
XIII—Fuses (Economy Fuse & Mfg. Co.)	
Refillable, 250-volt, 6, 30, 60, 100-amp	10 each
Refillable, 250-volt, 100-amp	5 each
Refillable, 250-volt, 200, 400-amp	3 each
Refillable, 600-volt, 30, 60, 100-amp	6 each
Refillable, 600-volt, 200, 400-amp	3 each
Renewal links, 250-volt, 6-amp	500
Renewal links, 250-volt, 15, 20, 25, 30-amp.	200 each
Renewal links, 250-volt, 40, 50, 60, 80-amp.	100 each
Renewal links, 250-volt, 100, 125, 150, 200-amp.	25 each

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Renewal links, 600-volt, 60, 100, 125, 150-amp.	10 each
Renewal links, 600-volt, 15, 20, 25, 30, 40, 50-amp.	25 each
XIV—Fuse Blocks, 2-wire, 30-amp., 250-volt	5
INSULATION AND INSULATORS	
XV—Insulation	
Empire cloth	2 sq. yds.
XVI—Insulation	
Fish paper	3 lb.
Tape, ¾-in. linen armature	4 rolls
Tape, ¾-in. adhesive	20 lb.
Tape, rubber	2 rolls
Tape, ¾-in. No. 1 varnished	3 rolls
Mica bond, Chicago Mica Co., No. 101, .025, .030, .035	1 sheet each size
Mica bond, Chicago Mica Co., No. 104, .025, .030, .035	1 sheet each size
Uncut mica, grade A	1 lb.
Asbestos cord, ⅛ in	2 lb.
Cotton sleeving, No. 1 white	1 lb.
XVII—Insulators	
Strain insulators, 2000-volt	2
Strain insulators, little giant	5
Glass cable insulators	10
Glass insulators	10
Porcelain knobs, split, No. 5½	50
Porcelain knobs, solid, No. 1, No. 3½ (Overstock now)	
McIntire sleeves	4
Fiber tubes, 5/16 in. x 1/16 in. x 3 in.	25
XVIII—Miscellaneous	
Battery bells, 3-in	2
Push buttons, wood	2
Buzzer	1
Samson cells, carbons	4
Samson cells, lids	2
Samson cells, jars	2
Contact for Recti bells, top and bottom	2 each
Leather nail heads	250
Heater plates	2
Lock washers, ⅜ in., ½ in., ⅝ in.	10 each
Carbon brushes (same as at present)	
XIX—Materials used but not stocked, in standard quantities:	
Wire—weather proof, Nos. 0000, 6, 8, 10	
Wire—magnet, d.c.c., Nos. 10, 11, 12, 17, 18	
Wire—resistance Climax, Nos. 16, 18	
Wire—annunciator, No. 18	
Circular loom, ⅜ in.	
Gang boxes, 4 in. x 4 in. and 4 in. x 6½ in.	
Sprague multiples for 1 in. conduit	
Porcelain tubes	
Porcelain cable insulators	
Annunciators, 3 and 10	
Carbons, for welding, several sizes	
Carbons, electrodes, several sizes	

low the drawers makes a convenient place for storing the cans of shellac and insulating paints and varnish. A shelf under the rest of the bench serves as a temporary storage place for paints, wire, and other materials.

A rack made of light angle iron and strongly braced is located a few feet from the end of the bench on which the coil winder is mounted, and is used for holding the reels of wire when coils are being wound.



Floor plan of repair shop, showing arrangement of work benches and equipment.



Here is the stock of spare armature and crane parts.

Armatures are stored on heavy wooden racks, shown at the left. Normally there are on hand as spares, one 65-hp. armature, one 35 hp., one 23 hp., one 9 hp. and six or seven 3 hp. besides one armature for the electric locomotives and one for each crane motor. The shelves at the right contain a complete set of gears and pinions for crane motors, spare pulleys, starting boxes and other miscellaneous equipment which is too heavy and bulky to be stored in cabinets.

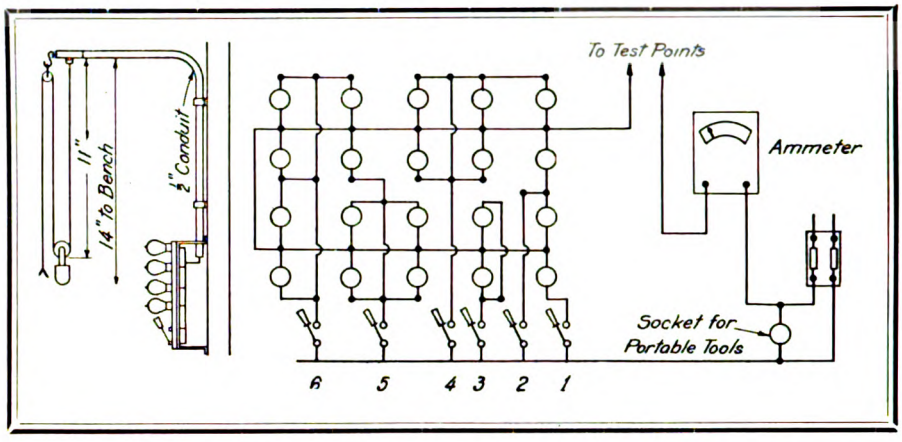
Between the reel rack and the row of lockers is a large wash basin.

Running at a right angle to the lockers, and separating the repair shop from the steam fitters' department, is a row of steel cupboards in which are stored small miscellaneous repair supplies. In this corner of the shop is also placed the chief electrician's desk and a locked cabinet containing our equipment of portable volt-, watt- and ammeter and other delicate testing instruments.

Up to the present we have been using air drying varnishes (Ajax or Sterling) on large armatures after rewinding, while small armatures, up to 3 hp., were baked in a home-made oven, consisting of a cabinet made from asbesto-board and heated by several resistance units which were wound in the repair shop. This oven, which is mounted on the wall, is shown in one of the illustrations accompanying this article.

A small winding machine for making magnet and other small coils, winding tape for the taping machine, and so on, is the final item of our re-

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Wiring diagram of lamp bank for testing purposes.

This bank contains twenty 40-watt Mazda lamps, with six switches for control and ammeter for showing current flow when testing small motors and so on. The lamps and switches are connected so that any number of lamps from 1 to 20 can be put in circuit. The diagram at the left shows how the test leads are brought out through ½-in. conduit at the edge, and 14 ft. above the top, of the bench. After leaving the conduit the leads pass over a small pulley suspended from the end of the conduit. A counterweight keeps the leads, which have a reach of 30 ft., out of the way when not in use.

pair shop equipment. This was made from an old sewing machine head and pattern plate. The driving spindle is fitted with a small drill chuck, to hold screws or bolts screwed into the magnet cores. A ⅛-hp. motor furnishes the power for turning the spindle. No heavy machine work, such as turning shafts and commutators, is done in the repair shop; nor would it pay to install the necessary equipment for doing it. All such work is taken care of in the general machine shop, which is well equipped to handle anything in the way of machine work.

It is the intention, however, to install a gas- or electrically-heated oven which will be large enough to accommodate any armature we may have to rewind.

The variety and extent of the electrical equipment in this plant, and the fact that alterations or additions are constantly being made, render it necessary to keep in stock a considerable amount of material and parts. These are kept in steel racks approximately 18 ft. long and 12 ft. high. These racks are double; that is, both sides are alike, so that material can be stored from either side. As will be seen from the illustration, there are two rows of open bins at the bottom; then come three rows of drawers, one deep and two shallow. Above the drawers are four rows of bins. The bins are, of course, used for storing large and bulky articles, while the drawers are reserved for small parts. A list of the materials and parts, with the minimum amount kept in stock, is given elsewhere in this article.

Two such racks are required to hold the stock of parts usually kept on hand, and are located in a screen-inclosed general store room occupying about the same space as the repair shop.

Spare motors, armatures, pinions and similar equipment is stored on racks and shelves in another section of the building, adjoining the repair shop but separated from it by a fire wall.

At the present time there is in stock one spare motor for the two electric locomotives and several other motors ranging in size from 3 to 25 hp. Inasmuch as trouble with our motors is usually located in the armature the following armatures are kept on hand: One 65-hp., one 34-hp., one 23-hp., one 9-hp. and six 3-hp., besides one armature for the electric locomotives and each crane motor.

These armatures, each is fitted with a set of new bearings, are stored on heavy wooden racks. Metal tags fastened to the racks, beside the armatures, give the size or the motor to which they belong.

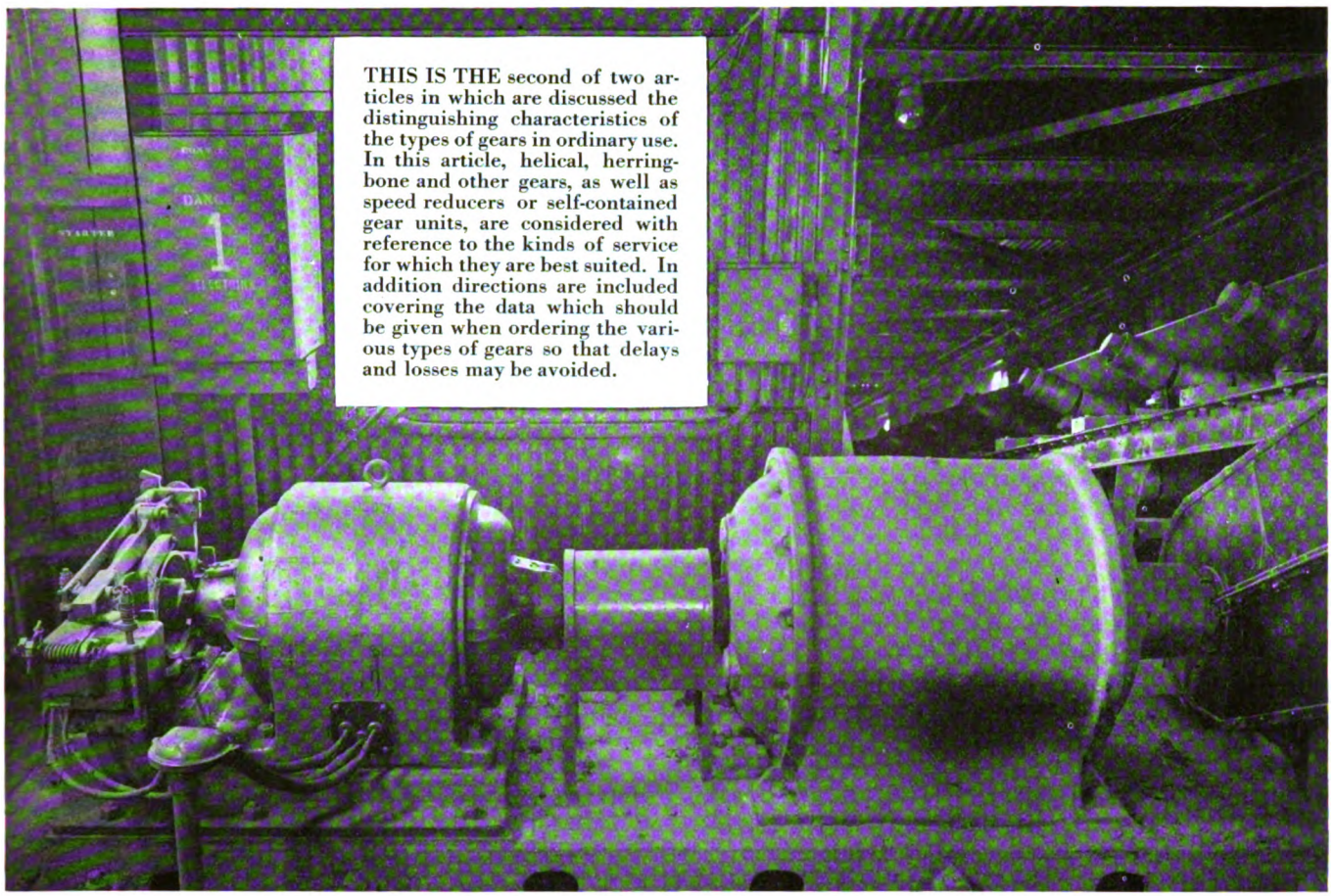
A complete set of pinions and gears for each motor of the several cranes in use, together with spare pulleys, starting boxes and the like, are kept on shelving convenient to the armature racks.



Rack for storing supply of parts and materials.

Two racks like this are required to store the supply stock. These racks, which are 18 ft. long and 12 ft. high, are built double so that material can be stored from both sides and are home-made of light steel construction. The drawers are reserved for small parts, while bulky articles are placed in the open bins, above and below.

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THIS IS THE second of two articles in which are discussed the distinguishing characteristics of the types of gears in ordinary use. In this article, helical, herringbone and other gears, as well as speed reducers or self-contained gear units, are considered with reference to the kinds of service for which they are best suited. In addition directions are included covering the data which should be given when ordering the various types of gears so that delays and losses may be avoided.

This is a 40-hp. speed-reducing set which drives a coke conveyor in a by-products coke plant. The speed reducer has a ratio of 40 to 1, giving, in this case, a final speed of 21.5 r.p.m.

Some Practical Information About

Gears and Speed Reducers

Together With Directions for Ordering Them That Will Help to Prevent Delays and Avoid Errors

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

IN AN article which appeared in the February, 1923, issue of INDUSTRIAL ENGINEER, practical details on the use of spur gears were discussed. Mention was made of the fact that although spur gears are extensively used, there are certain service and operating conditions which call for other types of gears. For instance, the teeth of spur gears make contact over their entire length, and the load is first thrown on the end of the tooth, producing a sudden and severe strain on the metal. Under such conditions the transmission of power through the gears is practically a series of impacts.

Helical Gears were developed, in part at least, to overcome this defect. Helical gears have oblique teeth, that is, teeth are placed at an angle to the axis of the gears. The form of tooth employed is the involute, or a close approximation to it. In well-made helical gears there is a greater amount of rolling action on the teeth than with ordinary spur gears of the same face, and the load is put on and removed slowly, so that shocks and severe strains are avoided. The chances of breakage are thus reduced and operation is more quiet.

Helical gears possess one disadvantage, however, in that they exert a more or less serious axial or side thrust, due to the action of the teeth. The thrust varies with the angle of the spiral; so the angle is made only large enough to insure the gradual and accurate meshing of a set of teeth while a preceding set is being released. This will be accomplished if the angle is such that the end of one tooth will just overlap the end of the adjoining tooth. The wider the face of a helical gear, therefore, the smaller the angle of spiral may be made, with a consequent reduction in side thrust produced.

One common method of overcoming this side thrust is to place two helical gears of opposite spiral on the same shaft, so that the thrust of one neutralizes that of the other. If necessary or desirable, they may be mounted some distance apart, or

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they may be mounted or even bolted together to form what is known as a herringbone gear.

Herringbone Gears Are Suitable for Heavy Drives

Herringbone Gears are sometimes referred to as double helicals and virtually consist of two helical gears of opposite spiral in one face. They do not, therefore, produce any unbalanced axial thrust.

Cutting the teeth of herringbone gears presents certain mechanical difficulties and any one of several different procedures may be followed. For example, two helical gears of opposite spiral may be accurately finished on adjoining sides and firmly fastened together. Another method is to make the rim in two pieces each of which is one-half of the width of the face of the finished gear, and separate from the spider. The two halves of the rim are then cut as helical gears and assembled together on the spider. Herringbone gears may be made in one piece either by cutting a groove through the center of the face, so that the cutter can run out at the groove, or the teeth may be staggered, for the same purpose.

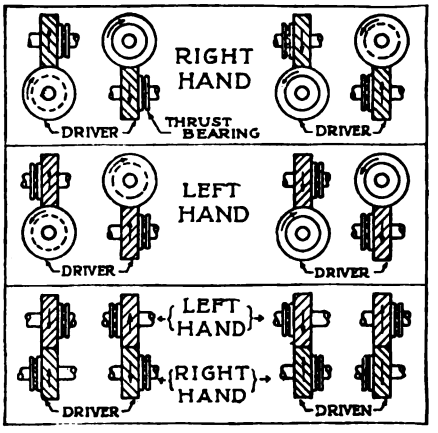
Comparatively small herringbone gears are capable of transmitting large amounts of power and also permit of greater single speed reduction than is possible with spur gears, because of the multiple tooth engagements and consequent safer meshing. In addition they operate with a minimum of noise and vibration. They find wide application, therefore, in the reduction of speed from motors and steam turbines. In addition, they are very satisfactory for and are much used on hoisting apparatus, rolling mill machinery and similar applications.

Internal Gears differ from ordinary spur and other gears in that the teeth are cut in the inner surface of the rim, instead of the outer. They can be obtained as plain rings for mounting in casings or otherwise, or provided with webbed or spoked backing the same as ordinary gears.

With internal gears the pinion and gear rotate in the same direction and they are largely used for speed reduction without reversal of direction of rotation, thereby saving one gear and its bearings. Other advantages are that as compared with spur and other gears the reduced shaft centers allow a greater speed reduction in the same space, also there is more bearing contact between the teeth, giving greater durability and steadier movement.

Bevel Gears Are Employed for Angular Drives

The preceding types of gears are employed for transmitting power between parallel shafts. There are many instances, however, where shafts in the same plane, but at an angle to each other, must be connected. For this purpose bevel gears are employed.



Direction of rotation and thrust of helical and spiral gears.

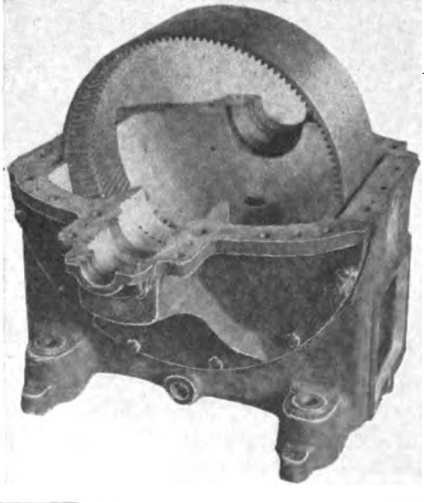
When the direction of rotation of the driver is known, the rotation of the driven gear can be determined from the diagram, which also shows where thrust bearings should be placed. This illustration is reproduced with acknowledgments to Boston Gear Works, Norfolk Downs, (Quincy), Mass.

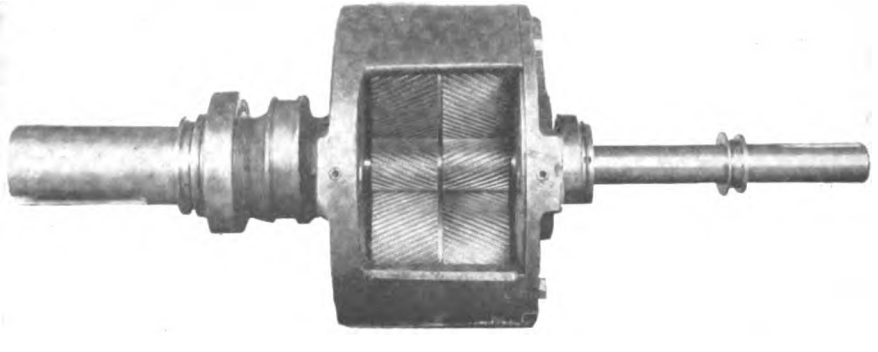
Bevel Gears can be designed to operate at any angle, but are more often made for right-angle drives. Changing of speed is accomplished, as in other gear drives, by making one of the gears, called the pinion, smaller than the other. A pair of gears of the same diameter, running at right angles to each other, are generally known as miter gears.

The blanks or wheels on which bevel gear teeth are cut are of various forms, depending on the size of the gear, the material from which it is made, the service and so on. The pinion type of blank is used largely for gears having a small number of teeth and small pitch cone angle. For larger gears the web form is appropriate.

Bevel gears and pinions are made of cast iron, steel or brass, according to the service required. The smaller the pitch, the greater is the efficiency of a gear, provided that too wide a face is not required to transmit the power. When dealing with bevel and miter gears it must be remembered, however, that they are designed to operate in pairs and are not interchangeable, as are spur gears. A small miter will not run with a large miter, nor can a change of speed be effected by changing one of a pair of bevel gears.

The third condition under which power may have to be transmitted is when the shafts are at any angle

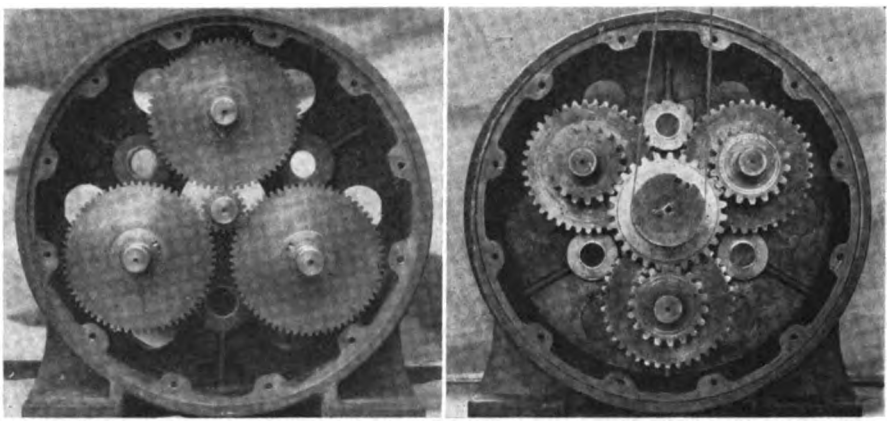




Working parts of one design of planetary speed reducer.

The upper illustration shows the lower half of the casing with the herringbone internal gear. The cage with the low speed shaft and intermediate gears, one has been removed here, and the high speed shaft and pinion are shown below. The internal gear is held rigidly in place by keys. As the high speed shaft revolves, its pinion rotates the intermediate gears which mesh with the internal gear. As the internal gear is stationary, the intermediate gears must rotate about the high speed shaft, causing the cage or low speed member in which they are mounted to rotate.

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Interior view of one type of spur-gear speed reducer.

The left illustration shows the high-speed end of the reducer with the head removed, while a corresponding view of the low speed end is shown at the right. It will be seen that this make of reducer does not employ an internal gear. In operation a central driving pinion on the high speed shaft meshes with and drives three countershaft gears. Three pinions integral with these gears surround and drive another gear, which in turn drives three countershaft gears in the low-speed end. Three countershaft pinions integral with these gears drive the centrally-located, low-speed shaft. The high and low speed shafts are in line and rotate in the same direction. This is known as a double-type reducer and gives four reductions.

not in the same plane. Under these circumstances worm or spiral gears are employed.

Worm and Spiral Gears Connect Shafts Not in the Same Plane

Worm Drives comprise a worm provided with one or more continuous threads, somewhat like a screw thread, and a worm gear with which it meshes. The number of threads required for a worm is found by dividing the number of teeth in the worm gear by the velocity ratio desired. Thus, if a worm gear has sixty teeth and a velocity ratio of 30 to 1 is required, 60÷30=2, which is the number of threads required for the worm. For worm gear drives, "hand" means the direction of travel, either right or left, the same as for a screw. Lead means the distance which a given thread advances in one revolution of the worm. Pitch is the distance from center to center of two adjacent threads. The pitch and the lead are equal for a single-thread worm. For a double-thread worm the lead is twice the linear pitch, three times for a triple-thread and four times for a quadruple-thread. For example, a ½-in. pitch worm, quadruple-thread, would be 2-in. lead.

Worm gears are similar in general design and construction to spur gears. The face may be made either straight or concave. The teeth may be cut parallel to the axis of the worm gear, as in spur gears, or they may be cut at a small angle to the axis.

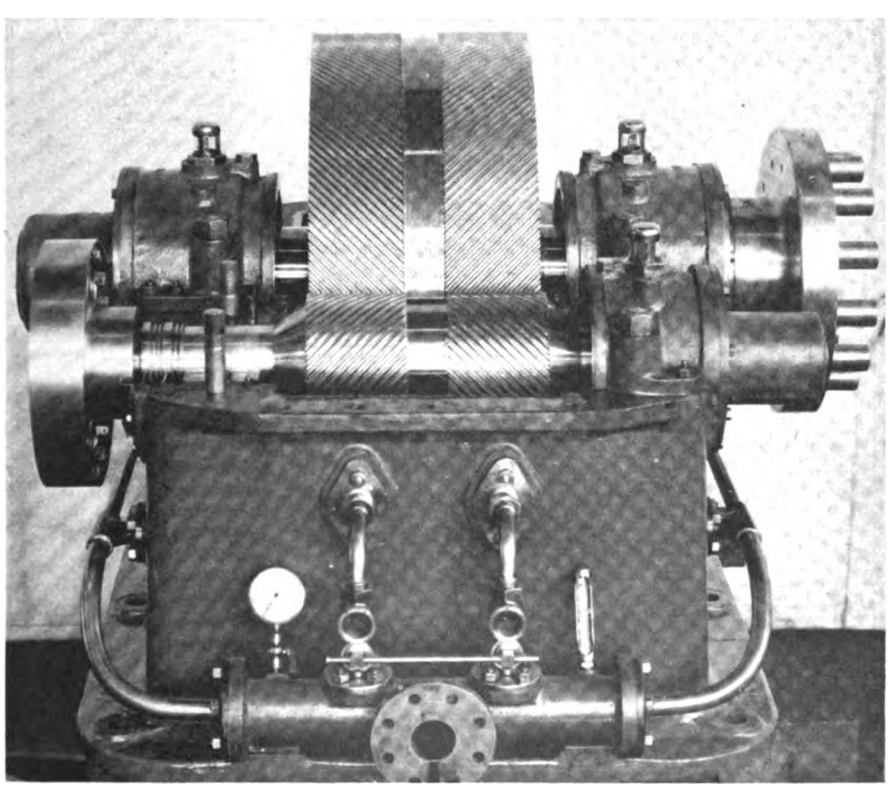
The materials from which the worm and gear are made have a good deal to do with the life and efficiency of a worm drive. The usual combination is a steel worm and a cast-iron cut worm gear, and for ordinary service gives good results. For high speeds or especially heavy duty a hardened steel worm and a phosphor-bronze worm gear are usually recommended.

It is important to note that the bearings for a worm drive must withstand both radial and thrust loads on the worm and usually the worm gear shaft also; a radial bearing must therefore be provided to support the worm and maintain it in the proper relation to the gear, while some form of thrust bearing must also be installed to take the thrust along the axis of the worm. This applies also to the wheel shaft.

The efficiency and durability of a worm drive depend to a very large extent on the use of the proper lubricant in sufficient quantity to prevent heating and consequent undue wear. Although the action in a well-designed worm drive is largely a rolling contact between the worm threads and the wheel teeth, with as little sliding action as it is possible to obtain, it is necessary to use a lubricant which possesses sufficient body to form and maintain a film between the teeth, and still not be too heavy to flow properly. For the purpose of securing better lubrication and maintaining alignment, worm drives are usually mounted in oil-tight and dust-proof housings, the lower part of which is filled with oil so that the worm operates in a bath of lubricant.

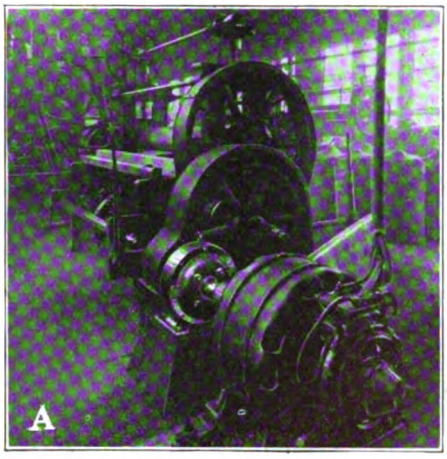
Worm drives have many applications where smoothness of action, large reductions in speed and increase in effective power are desired.

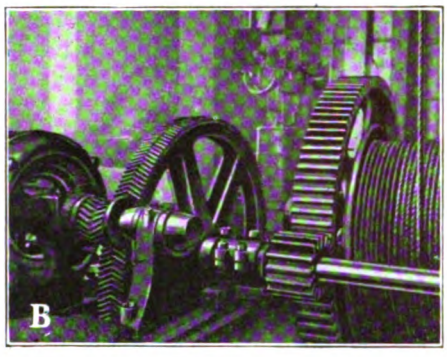
Spiral Gear is the term usually applied to gears which have angular teeth and the shafts or axes usually

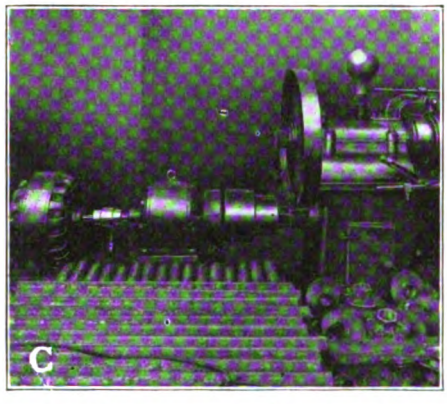


Herringbone gear unit for driving centrifugal pump. This unit is rated at 825 hp., with a reduction of 3700 to 900 r. p. m.

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Some Uses of
Gears and Gear Units
in Industrial Works

A—A speed reducer, ratio 6 to 1, eliminates one set of gears in the drive for this bleaching machine in the plant of Western Shade Cloth Co., Chicago, Ill.

B—Combination of herringbone and spur gears for speed reduction on hoisting drum. A herringbone gear runs more quietly and smoothly than a spur gear and makes the first reduction.

C—This speed reducer, ratio 10 to 1, takes the place of belts, shafts and pulleys for operating a 2-in. bolt cutter in shops of Union Draft Gear Co., Chicago, Ill.

D—An installation of speed reducers, ratio 17½ to 1, connected between motors and pumps in plant of Republic Chemical Co., Pittsburgh, Pa.

E—Saving space by using speed reducer, mounted overhead, in gas plant of Monongahela Valley Traction Co., Fairmont, W. Va.

F—A place where open gearing could hardly be used. This 3½-hp. speed reducer, ratio 140 to 1, drives a salt plunger feeder in a by-products coke plant.

G—Five-horsepower speed reducers, ratio 24 to 1, driving conveyor in plant of Stein-Hall Manufacturing Co., Chicago, Ill.

H—Another use for speed reducers in plant of Stein-Hall Manufacturing Co. Here is a battery of mixers driven through 7½-hp. reducers having a ratio of 22.4 to 1.

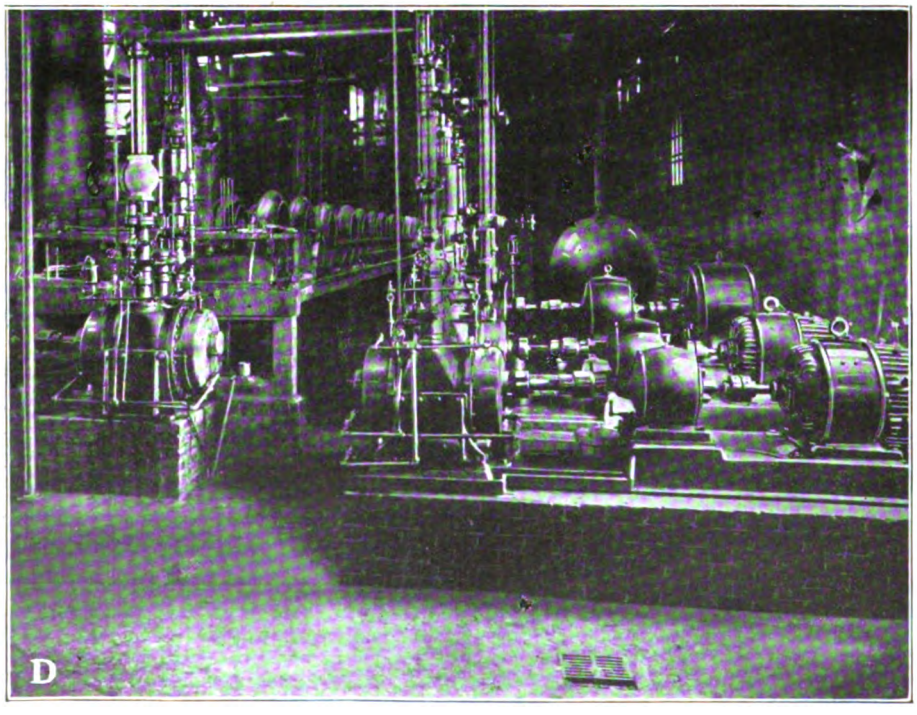
I—A compact and safe speed-reducing drive for billet-handling device in plant of The Pullman Co., Chicago, Ill.

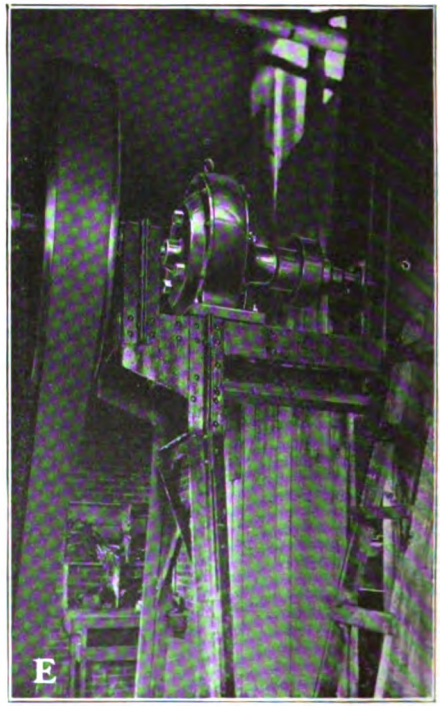
J—One way of obtaining the necessary reduction in speed. This is the drive for a dragline conveyor.

K—Here is another way of obtaining a reduction in speed—in this case from 1,800 r.p.m. to 138 r.p.m. This shows an ammonia compressor driven through a 15-hp. speed reducer.

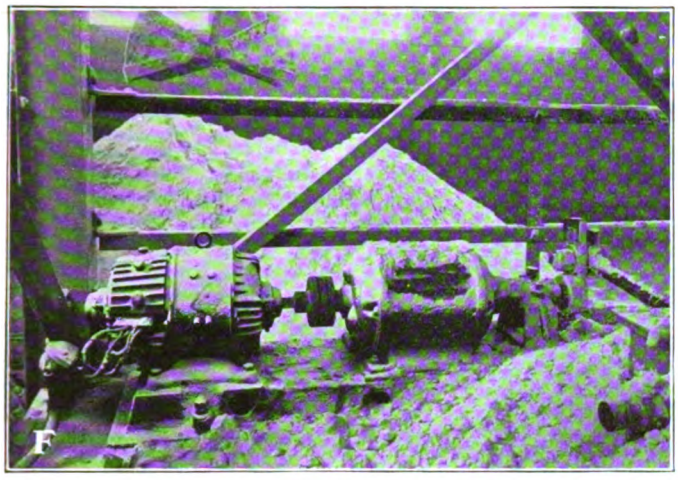
L—A 5-hp. speed reducer, ratio 13.26 to 1, driving a belt conveyor feeding to a shaking screen in a by-products coke plant.

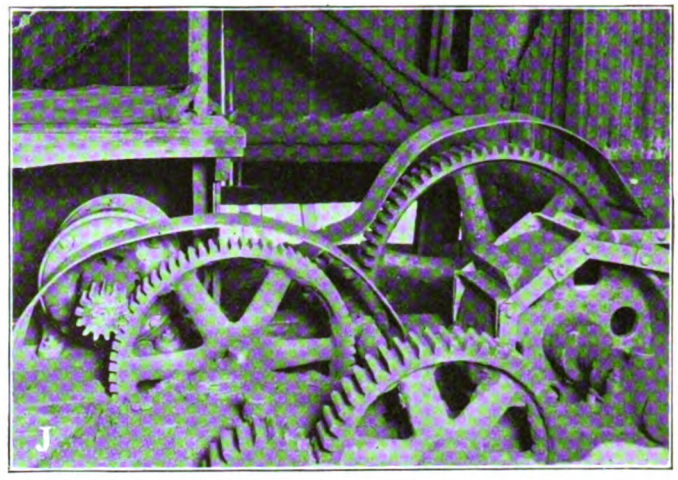
M—Little space is required by this speed-reducing drive for a slurry tank in a large cement mill. The reducer has a ratio of 4.8 to 1.

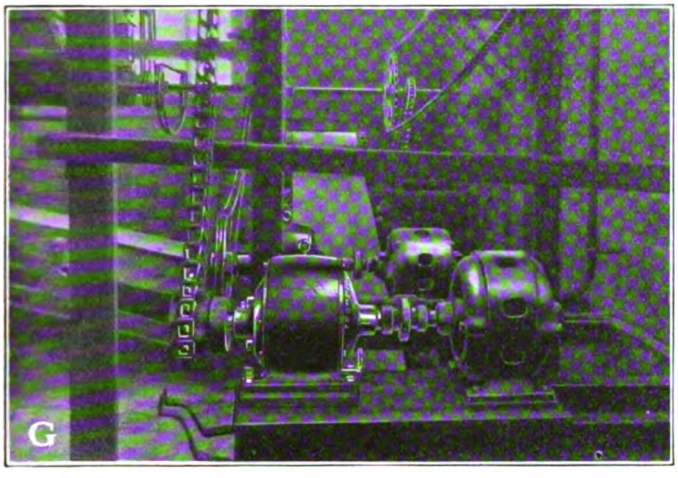


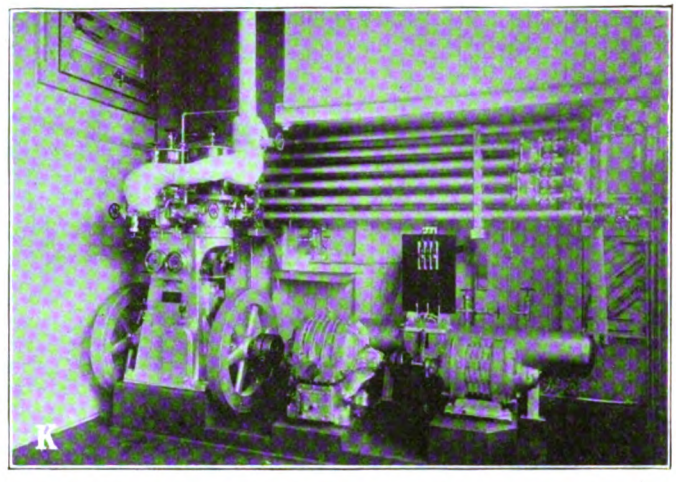


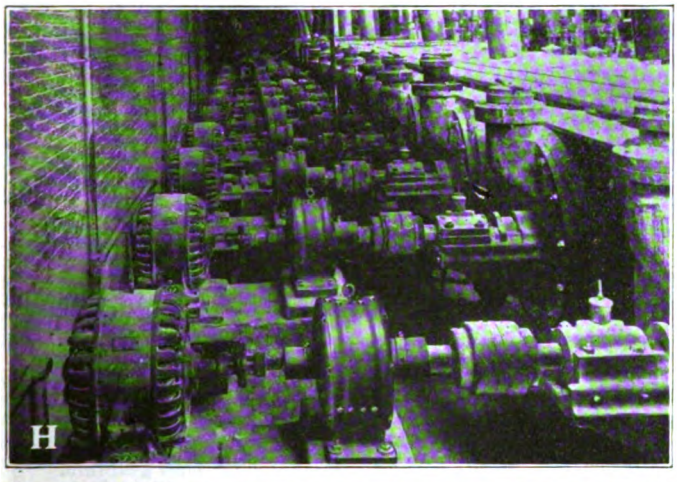
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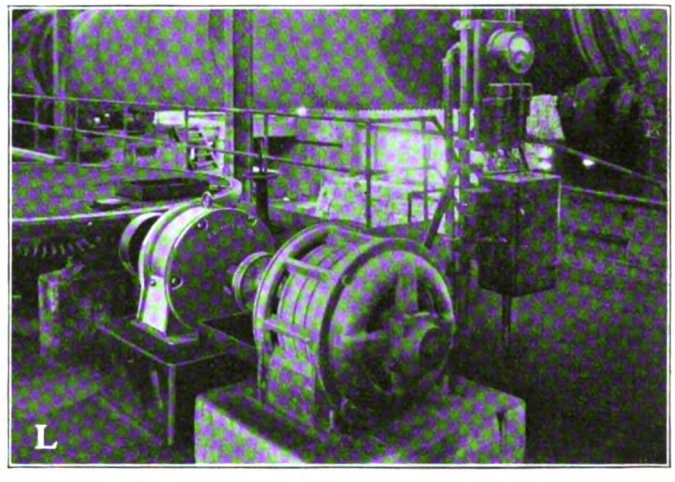

F

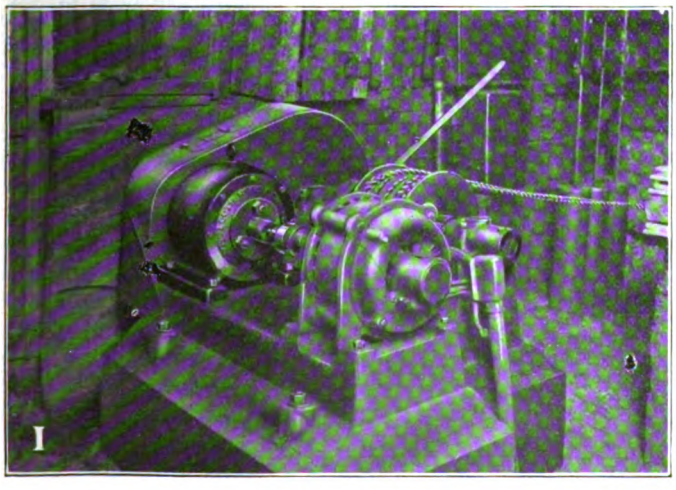

J

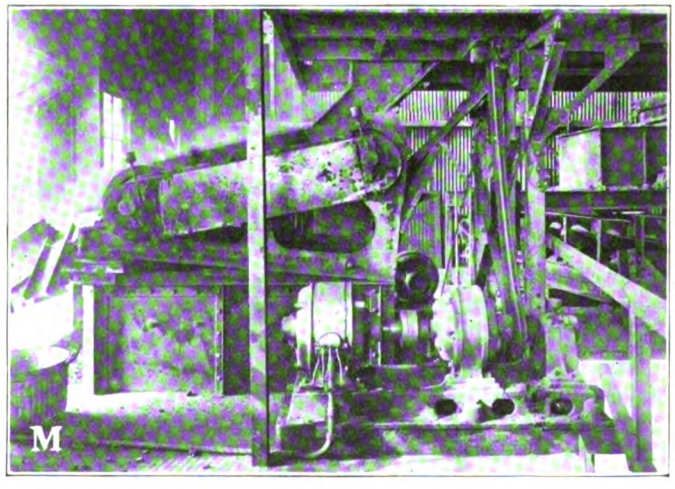

G


K


H


L


I


M

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at right angles. Spiral gears can be used in place of bevel gears, and give smoother action as well as permit of a greater speed ratio within a given space.

When calculating speed ratios for spiral gears the driving gear may be considered as a worm having as many threads as there are teeth, and the driven gear regarded as the worm wheel with its number of teeth. One revolution of the driver will turn a point on the pitch circle of the driven gear as many inches as the lead of the teeth of the driver. Divide this by the circumference of the pitch circle of the driven gear to obtain the revolutions of the driven gear.

Spiral gears are usually made with a tooth angle of 45 deg. The required speed ratios can then be obtained by varying the diameter, as with spur or bevel gears. When the angles are not 45 deg. the gear with the greater angle must always be used as the driver. The two gears may both be cut right-hand or left-hand for operation at a right angle. If one gear is cut right-hand and the other left they can be used on parallel shafts.

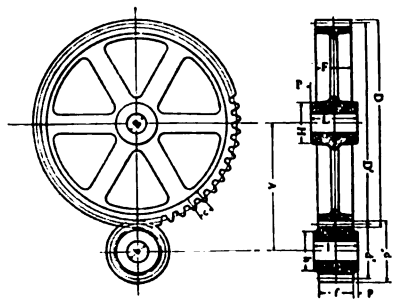
There are two points in connection with the use of spiral gears which sometimes cause confusion: the direction of rotation and the direction of the axial thrust. An accompanying diagram shows the direction of rotation for both right-hand and left-hand driver and driven gear and also the direction of the thrust.

Self-Contained Gear Units Often Take the Place of Open Gearing

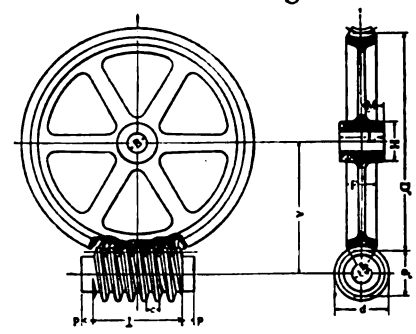
Under the best conditions, open gearing possesses certain objectionable features, such as the ever-present possibility of injury to employes, difficulty of proper lubrication, noise and the increased wear from dust and grit usually present in the air. With the rapid increase in the use of high-speed prime movers, electric motors and steam turbines, there has come a demand for compact and self-contained gear units which are quiet in operation, require the minimum of attention and will give the desired reduction or increase in speed.

There is now on the market a large number of so-called speed transformers, ranging from the fractional (*Continued on page 171.*)

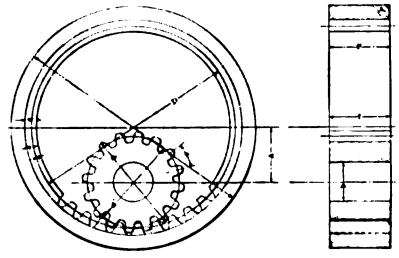
Data Which Should Be Given When Ordering Gears



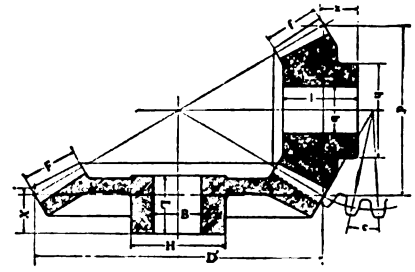
Spur Gears or Pinions. State (1) whether teeth shall be cut or cast. (2) Material. (3) Number of teeth. (4) Pitch diameter, *D'* or *d'*. (5) Width of face, *F* or *f*. (6) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (7) Bore, *B* or *b*. (8) Whether keyseated or setscrewed. If keyseated, whether straight or taper. Give width and depth of keyseat. With taper keyseat where hub is not located centrally, state from which end of hub key drives. (9) Length of hub, *L* or *l*. (10) Projection of hub, *P* or *p*. (11) Diameter of hub, *H* or *h*. (12) Outside diameter, *D* or *d*. (13) Distance between centers, *A*.



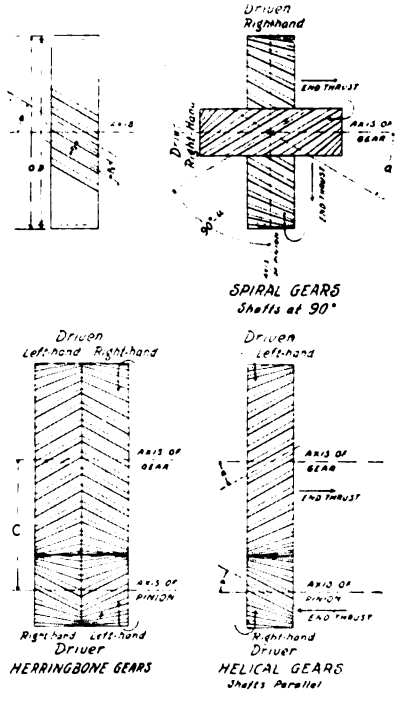
Worm Gears or Worms. State (1) whether teeth shall be cut or cast. (2) Material. (3) Number of teeth. (4) Pitch diameter, *D'* or *d'*. (5) Width of face, *F*. (6) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (7) Bore, *B* or *b*. (8) Whether keyseated or setscrewed. If keyseated, whether straight or taper. Give width and depth of keyseat. With taper keyseat, state from which end of hub key is driven. (9) Length of hub, *L* or *l*. (10) Projection of hub. (11) Diameter of hub, *H* or *h*. Distance between centers, *A*. (12) Length of worm, whether right or left hand, and number of threads.



Internal Gears or Pinions. State (1) Material. (2) Number of teeth. (3) Pitch diameter, *D'* or *d'*. (4) Face, *F* or *f*. (5) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (6) Rim diameter, *R*. (7) Outside diameter of pinion, *a*. (8) Bore of pinion, *b*. (9) Whether taper or straight keyway, width or depth. (10) Centers, *A*.



Bevel Gears or Pinions. State (1) whether teeth shall be cut or cast. (2) Material. (3) Number of teeth. (4) Pitch diameter, *D'* or *d'*. (5) Face, *F* or *f*. (6) Pitch, circular, *C* or *c*, or diametral (number of teeth to each inch of pitch diameter). (7) Bore, *B* or *b*. (8) Whether keyseated or setscrewed. If taper keyseat is used which end does key drive from? (9) Length of hub, *L* or *l*. (10) Backing, *X* or *x*. (11) Hub diameter, *H* or *h*.



Spiral, Helical and Herringbone Gears or Pinions. State (1) angle of tooth with axis of rotation, *a*. (2) Normal diametral pitch, *Pd*. (3) Circular pitch, *Pc*. This pitch varies with the angle of tooth. (4) Number of teeth in gear and in pinion. (5) Pitch diameter of gear, *D*, and pinion, *d*. (6) Outside diameter of gear, *O*, and pinion *o*. (7) Center distance, *C*. (8) Bore. (9) Whether keyseated or setscrewed. The sum of the tooth angles of a set of spiral gears with shafts at right angles must be 90 deg. The tooth angles of helical or herringbone gears are the same for both gear and pinion and can be made any angle to suit conditions. For a set of spiral gears, both must be right-hand or left-hand. In a set of helical gears, one must be right-hand and the other left-hand. Each of a set of herringbone gears is made of right and left-hand sections. When ordering herringbone gears with unequal hub projections state the hand for either section. The sizing of spiral gears differs from the sizing of spur gears on account of the angle of teeth. In spur gears, one diametral pitch, one inch is the addendum or diameter for one tooth. In spiral gears this addendum or diameter for one tooth is the secant of the angle of tooth. The secant of the angle of tooth, when divided by the diametral pitch to be used is the addendum for that pitch and when this addendum is multiplied by the number of teeth required, the product is the pitch diameter for that gear. The greater the angle of tooth, the larger the diameter of the gear.

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GROUPING THE COILS of induction motors and connecting the groups for different series and parallel windings are two every-day jobs in every repair shop. This is the first of a series of articles in which Mr. Roe presents some diagrams and tables which help to make these jobs easy. He covers two-phase and three-phase windings of two to twenty-four poles. He explains the use of both long and short jumpers. He tells how many coils are placed in each group. This is an especially difficult thing to figure if the groups have unequal numbers of coils. By following his diagrams the job is made comparatively simple.

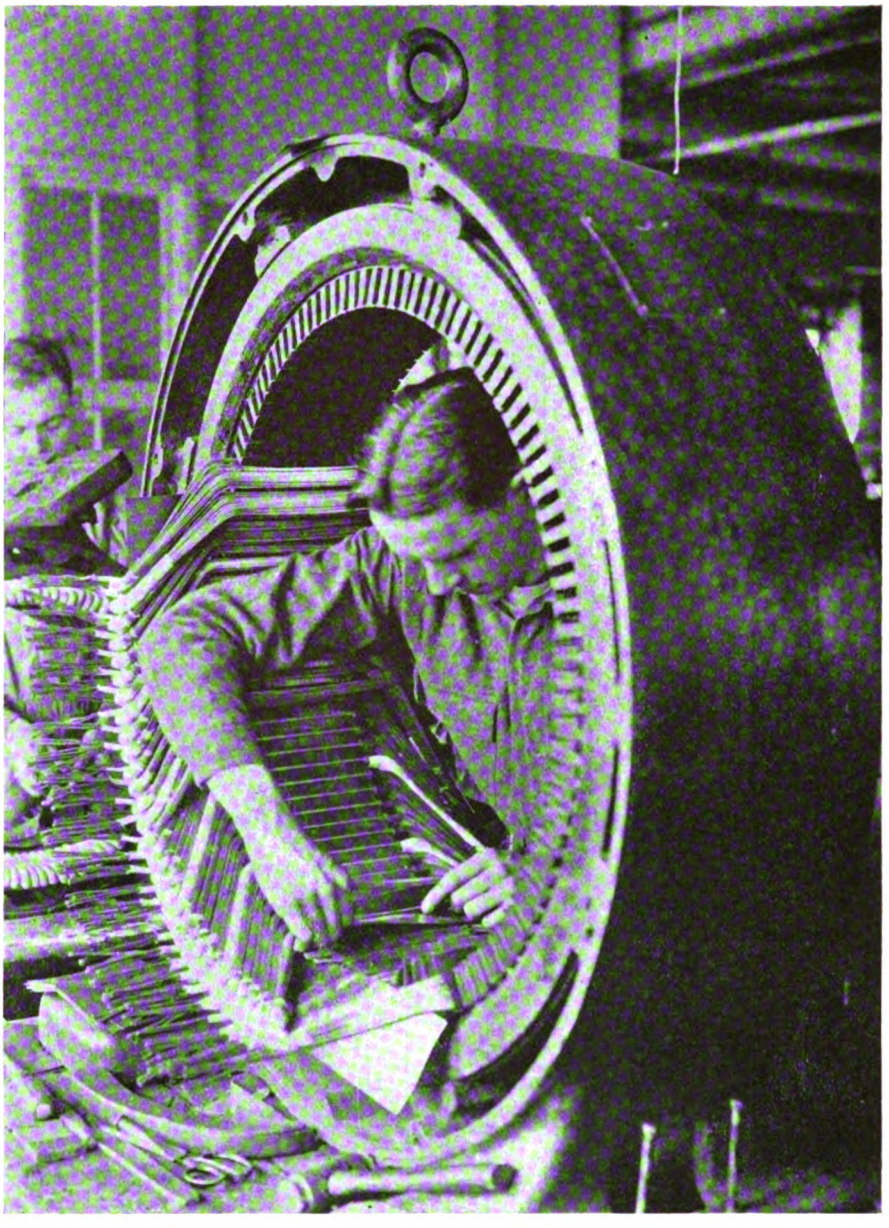
Tables and Diagrams for

Connecting Induction Motors

Showing How Coils Are Grouped and the Series and Parallel Connections Are Made

By A. C. ROE,

Shop Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company



IN connecting induction motors the main job revolves around the proper grouping of the coils and the connecting of these groups. In this series of articles I am going to take up just these things and discuss the step-by-step details from the viewpoint of the shop man who does the work. The complete series will cover two-phase and three-phase windings having from two poles to twenty-four poles. This range covers almost all of the cases that will arise in practice. The diagrams and the data include both the short jumper and the long jumper connections for windings with four poles to twelve poles. For all the other numbers of poles (from fourteen to twenty-four and also two poles) the information covers only the short jumper. This short jumper gives what is called throughout these articles a "top-to-top" connection in which the adjacent pole-phase groups are connected together. The long jumper gives what is called a "top-to-bottom" connection in which all similar pole-phase groups are connected together, that is, every alternate group. This means that all north poles are connected in series and from the last north pole a short jumper is used to connect to the south poles which are likewise in series. Where the windings have sixteen poles to twenty-four poles, a top-to-top connection only is given because on larger machines only the short jumper should ordinarily be used. The top-to-bottom jumpers would be quite long and awkward to handle. Of course there are a few cases when the long jumper is used for such machines.

On smaller machines the long jumper makes a neater appearing job and is easier to connect. Wherever the letters *T-T* appear in these diagrams this means that a top-to-top connection is shown. Likewise the letters *T-B* mean that a top-to-bottom connection is employed.

The Tables Tell How Many Coils Must Be in Each Group

In connecting an induction motor, the winding must first be connected into pole-phase groups. Therefore, the first operation that will be dealt with in this article will be how to determine the number of coils which must be in each group. Later on, the methods of connecting the groups together will be explained. The number of coils which should be connected together in each group is given in the *Main Table* and in the other tables which are designated as

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Main Table—Number of Coils Per Group in Winding

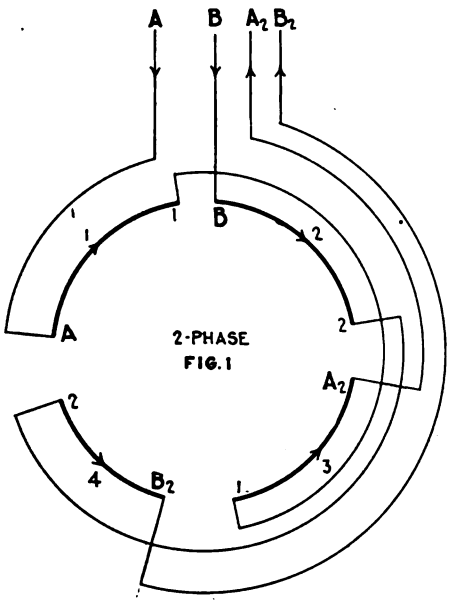
This table gives the number of coils in each group for windings having equal groups, that is, the same number of coils in each group. Each letter in this table indicates where equal groupings are not possible and that the unequal grouping will be found in other tables identified by those letters. A small (ᵏ) in this Main Table indicates that a coil must be killed in each group when this letter appears in this table. If this small (ᵏ) does not appear in this Main Table for the particular connection then no coil is killed even though the (ᵏ) is present in other tables. An asterisk (*) in this Main Table means that when consulting other tables which are referred to in this Main Table, the proper grouping will be found in the line in which an asterisk appears in conjunction with the figure which indicates the total number of coils. A blank space in this Main Table indicates that there is no practical grouping which can be made with the given number of coils and poles.

No. of Coils in Machine

No. of Poles	Connection \ Phases	12	18	24	36	48	54	60	62	72	80	84	86	90	96	104	108	120	128	135	144	150	156	160	168	180	216	240	Connection \ Phases	No. of Poles
		2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3	2 3		
2	Series	3 2	A 3	6 4	9 6	12 8	A 9	15 10	A B	14 12	20	21 14		15	24 16	26	27 18	30 20	32		36 24	25	39 26	40	42 28	45 30	54 36	60 40	Series	2
	2 Parallel	3 2	A 3	6 4	9 6	12 8	A 9	15 10	A B	14 12	20	21 14		15	24 16	26	27 18	30 20	32		36 24	25	39 26	40	42 28	45 30	54 36	60 40	2 Parallel	
4	Series	C 1	D	3 2	C 3	6 4	C D	C 5	C D	9 6	10 D	C 7	C D	C D	12 8	13 D	C 9	15 10	16 D	C D	18 12	C D	C 13	20 D	21 14	C 15	27 18	30 20	Series	4
	2 Parallel	C 1	D	3 2	C 3	6 4	C D	C 5	C D	9 6	10 D	C 7	C D	C D	12 8	13 D	C 9	15 10	16 D	C D	18 12	C D	C 13	20 D	21 14	C 15	27 18	30 20	2 Parallel	
	4 Parallel	1		3 2	3 2	6 4		5	D	9 6	10 D	C 7	C D	C	12 8	13	C 9	15 10	16	D	18 12	C D	C 13	20 D	21 14	C 15	27 18	30 20	4 Parallel	
6	Series	1	E 1	2 F	3 2	4 F	E 3	5 F	E F	6 4	E F	7 F	E F	E 5	8 F	E F	9 6	10 F	E F	E F	12 8	E F	13 F	E F	14 F	15 10	18 12	20 F	Series	6
	2 Parallel	1	E* 1	2 F	3 2	4 F	E* 3	5 F	E F	6 4	E F	7 F	E F	E* 5	8 F	E F	9 6	10 F	E F	E* F*	12 8	E* F	13 F	E F	14 F	15 10	18 12	20 F	2 Parallel	
	3 Parallel	1		2	3 2	4	3	5	E	6 4	Eᵏ	7	E	5	8	Eᵏ	9 6	10	Eᵏ F	Eᵏ	12 8	E	13	Eᵏ	14	15 10	18 12	20	3 Parallel	
	6 Parallel	1	1	2	3 2	4	3	5	E	6 4	Eᵏ	7	E	5	8	Eᵏ	9 6	10	Eᵏ F	Eᵏ	12 8	E	13	Eᵏ	14	15 10	18 12	20	6 Parallel	
8	Series			G 1	G H	3 2	G H	G H	G H	G 3	5 H	G H	G H	G H	6 4	G H	G H	G 5	8 H	G H	9 6	G H	G H	10 H	G 7	G H	G 9	15 10	Series	8
	2 Parallel			G 1	G H	3 2	G H	G H	G H	G 3	5 H	G H	G H	G H	6 4	G H	G H	G 5	8 H	G H	9 6	G H	G H	10 H	G 7	G H	G 9	15 10	2 Parallel	
	4 Parallel			G 1	Gᵏ H	3 2	Gᵏ	Gᵏ H	Gᵏ H	G 3	5	Gᵏ H	Gᵏ H	G Hᵏ	6 4	G Hᵏ	Gᵏ H	G 5	8 Hᵏ	Gᵏ H	9 6	Gᵏ	Gᵏ H	10 H	G 7	Gᵏ H	G 9	15 10	4 Parallel	
	8 Parallel				Gᵏ	3 2	Gᵏ			3	5	Gᵏ	Gᵏ		6 4	Hᵏ	Gᵏ	5	8 Hᵏ	Gᵏ	9 6	Gᵏ	Gᵏ	10	7	Gᵏ	9	15 10	8 Parallel	
10	Series					K L	K L	3 2	K L	K L	4 L	K L	K L	K 3	K L	K L	K L	6 4	K L	K L	6 4	K L	K L	8 L	K L	9 6	K L	12 8	Series	10
	2 Parallel					K L	K L	3 2	K L	K L	4 L	K L	K L	K 3	K L	K L	K L	6 4	K L	K Lᵏ	6 4	K L	K L	8 L	K L	9 6	K L	12 8	2 Parallel	
	5 Parallel							3 2	K L	Kᵏ	4	Kᵏ	Kᵏ	3	Kᵏ	Kᵏ		6 4		Kᵏ L	K	5		8	Lᵏ	9 6	Lᵏ	12 8	5 Parallel	
	10 Parallel							3 2	K L	Kᵏ	4	Kᵏ	Kᵏ	3	Kᵏ	Kᵏ		6 4		Kᵏ	K	5		8		9 6	Lᵏ	12 8	10 Parallel	
12	Series			1	M 1	2 N	M N	M N	M N	3 2	M N	M N	M N	M N	4 N	M N	M 3	5 N	M N	M N	6 4	M N	M N	M N	7 N	M 5	9 6	10 N	Series	12
	2 Parallel			1	M 1	2 N	M N	M N	M N	3 2	M N	M N	M N	M N	4 N	M N	M 3	5 N	M N	M N	6 4	M N	M N	M N	7 N	M 5	9 6	10 N	2 Parallel	
	3 Parallel			1		2 N		M N		3 2		M N	M N	M N	4 N	M	M 3	5 N	M N	M N	6 4	M N	M N	M N	7 N	M 5	9 6	10 N	3 Parallel	
	4 Parallel			1	Mᵏ 1	2 N		Mᵏ N	Mᵏ N	3 2	M	Mᵏ N	Mᵏ N	Mᵏ N	4 N	Nᵏ	Mᵏ 3	5 N	M N	Mᵏ N	6 4	Mᵏ N	Mᵏ N	M N	7 N	Mᵏ 5	9 6	10 N	4 Parallel	
	6 Parallel			1	M 1	2		M	M	3 2		M	M	N	4 Nᵏ		M 3	5 N	M Nᵏ	M	6 4	Mᵏ Nᵏ	M	7 N	M 5	9 6	10 Nᵏ	6 Parallel	
	12 Parallel			1	1	2				3 2		M			4		3	5	N		6 4	Mᵏ Nᵏ		7	M 5	9 6	10	12 Parallel	
14	Series				P	P X	P X	P X	P X	P X	P X	3 2	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	6 4	P X	P X	P X	Series	14
	2 Parallel				P	P X	X	P X	P X	P X	P X	3 2	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	P X	6 4	P X	P X	P X	2 Parallel	
	7 Parallel											3 2	P X					Pᵏ	X					6 4				7 Parallel	
	14 Parallel											3 2	P X					Pᵏ	X					6 4				14 Parallel	
16	Series					R 1	R Y	R Y	R Y	R Y	R Y	R Y	R Y	R Y	3 2	R Y	R Y	R Y	4 Y	R Y	R 3	R Y	R Y	5 Y	R Y	R Y	R Y	R 5	Series	16
	2 Parallel					R 1	R Y	R Y	R Y	R Y	R Y	R Y	R Y	R Y	3 2	R Y	R Y	R Y	4 Y	R Y	R 3	R Y	R Y	5 Y	R Y	R Y	R Y	R 5	2 Parallel	
	4 Parallel					R 1		Y		R Y	R	Y	Y	R	3 2	R	Y	R Y	4		R 3		Y	5 Y	R Y	Y	R Y	R 5	4 Parallel	
	8 Parallel					R 1					R				3 2				4		R 3			5				R 5	8 Parallel	
	16 Parallel					1									3 2				4		3			5				5	16 Parallel	
18	Series				1	S	S 1	S Z	S Z	2 Z	S Z	S Z	S Z	S Z	S Z	S Z	3 2	S Z	S Z	S Z	4 Z	S Z	S Z	S Z	S Z	5 Z	6 4	S Z	Series	18
	2 Parallel				1	S	S 1	S Z	S Z	2 Z	S	S Z	S Z	S Z	S Z	S Z	3 2	S Z	S Z	S Zᵏ	4 Z	S Z	S Z	S Z	S Z	5 Z	6 4	S	2 Parallel	
	3 Parallel				1	S	S 1	S	S	2 Z	S	S Zᵏ	S Zᵏ	S Z	S Z	S	3 2	S Z	S Z	Z	4 Z	S	S	S	S	5 Z	6 4	S	3 Parallel	
	6 Parallel				1	S		S		2 Z		S	S	Z			3 2	S Z			4		S			5 Z	6 4	S	6 Parallel	
	9 Parallel				1		S 1			2				S			3 2				4			S		5	6 4		9 Parallel	
	18 Parallel				1		1			2							3 2				4					5	6 4		18 Parallel	
20	Series					T	T	T 1	T J	T J	2 J	T J	T J	T J	T J	T J	T J	3 2	T J		T J	T J	T J	4 J	T J	T 3	T J	6 4	Series	20
	2 Parallel					T	Tᵏ	T 1	T J	T J	2 J	T J	T J	Tᵏ J	T J	T J	T J	3 2	T J	Tᵏ	T J	T J	T J	4 J	T J	T 3	T J	6 4	2 Parallel	
	4 Parallel					T		T 1	T J	T J	2 J	T	T J	J	T J	T	T J	3 2	T J	J	T J	T J	T J	4 J	T J	T 3	T J	6 4	4 Parallel	
	5 Parallel							1	J	T	2			J	J		2	3 2		J		J		4		3		6 4	5 Parallel	
	10 Parallel							T 1	T J		2						2	3 2				J		4		T 3		6 4	10 Parallel	
	20 Parallel							1	J		2						2	3 2						4		3		6 4	20 Parallel	
22	Series						V	V	V	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	V U	Series	22
	2 Parallel						Vᵏ	V	V	V U	V U	V U	Vᵏ U	Vᵏ U	V U	Vᵏ U	V U	V U	V U	Vᵏ Uᵏ	V U	V U	V U	V U	V U	V U	V U	V U	2 Parallel	
	11 Parallel													Vᵏ						Vᵏ Uᵏ						Vᵏ			11 Parallel	
	22 Parallel													Vᵏ						Vᵏ Uᵏ						Vᵏ			22 Parallel	
24	Series					1	W	W	W	W 1	W O	W O	W O	W O	2 O	W O	W O	W O	W O	W O	3 2	W O	W O	W O	W O	W O	W 3	5 O	Series	24
	2 Parallel					1		W	W	W 1	W O	W O	W O	O	2 O	W O	W O	W O	W O	Oᵏ	3 2	W Oᵏ	W O	W O	W O	W O	W 3	5 O	2 Parallel	
	3 Parallel					1		W		W 1		W	W		2		W O	W			3 2	W Oᵏ			W	W O	W 3	5	3 Parallel	
	4 Parallel					1		Wᵏ		W 1	W	O	O		2 O		Wᵏ O	W O	W		3 2	W Oᵏ	W O	W O	W O	O	W 3	5 O	4 Parallel	
	6 Parallel					1		W		W 1		W	W	O	2		W O	W	O	Oᵏ	3 2	W Oᵏ	W	W	W	W O	W 3	5	6 Parallel	
	8 Parallel					1				1	W				2 O			O	W		3 2	W Oᵏ		W	O		3	5 O	8 Parallel	
	12 Parallel					1				W 1					2		O	W			3 2	W Oᵏ			W	O	W 3	5	12 Parallel	
	24 Parallel					1				1					2						3 2	W Oᵏ					3	5	24 Parallel	
No. Coils		12	18	24	36	48	54	60	62	72	80	84	86	90	96	104	108	120	128	135	144	150	156	160	168	180	216	240	No. Coils	

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Two-Pole Windings



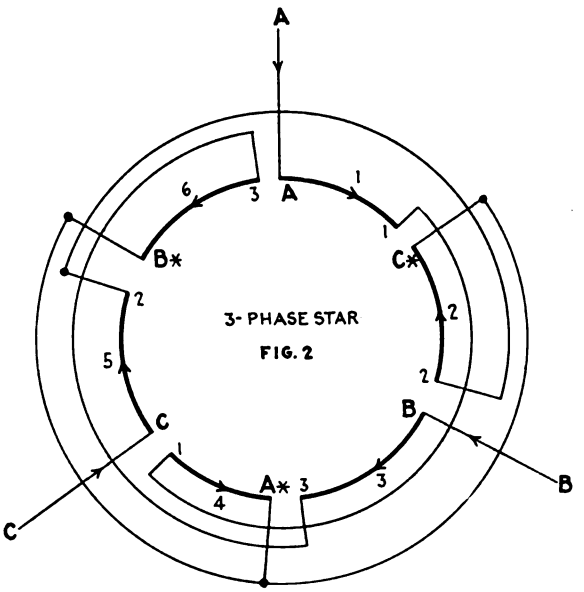


Chart A, Chart B, Chart C, etc. The *Main Table* gives directly the number of coils in each group if the winding is an "equal" winding. Throughout this discussion the term "equal" winding will mean that all of the coil-groups have the same number of coils. If the winding is an "unequal" winding (that is all the groups do not have the same number of coils) this fact will be indicated by a letter in the *Main Table* which will refer to one of the charts.

Therefore, the first thing to do in any case is to consult the *Main Table.* The columns in this table are arranged under the general heading of *Number of Coils in Machine.* The top row of figures refers to this heading and it should be remembered that the number of coils in the machine, and not the number of slots, is designated. Under each figure representing the number of coils, a sub-division is made according to whether the machine is two-phase or three-phase. This is indicated by the figures 2 and 3 in the second line of the *Main Table.* In the left-hand column of the table will be found the figures referring to the number of poles in a machine. And the second column will show the type of connection such as series, two-parallel, etc.

We can best explain the method of finding the number of coils per group by using an example. Suppose, for instance, that we have a motor with thirty-six coils and we want to connect it for six poles two-phase with a two-parallel connection. Then, we look under the figure 36 in the top line of the *Main Table* and in the left-hand column under this figure, as the left-hand column is for a two-phase connection. In this column to the right of the figure 6, which indicates six poles, and the two-parallel connection, we find that there is a figure 3. This figure 3 is seven lines down in the body of the table and seven lines over to the right. This figure indicates that all of the groups must have three coils. This is an equal winding.

Suppose now, we have the same winding with thirty-six coils and want to connect it for eight poles, two-phase in two-parallel connection. Reading down the same column as before, and over to the right from the eight poles and two-parallel designations, we find the letter *G.* When we find a letter such as this, we know that the grouping will be unequal and that we must consult the chart designated by the letter in order to find out how to arrange the groupings. In this case, we consult *Chart G.* In this chart the column at the left refers to the number of coils in the winding while the figures in the body of the table tell the number of coils in each group. Thus we see that in the first group there are two coils, in the second group two coils, in the third group two coils, in the fourth group two coils, in the fifth group two coils, and so on. This is the way that the coils should be connected in groups. It will be noticed that in some of the groups a small letter *k* appears above and to the right of the figure indicating the number of coils. This letter *k* may be disregarded unless a similar letter *k* appears also in the *Main Table*

UNEQUAL COIL GROUPING
TWO-POLE

CHART A, TWO-PHASE					CHART B, THREE-PHASE						
No. Coils	Group No.				No. Coils	Group No.					
	1	2	3	4		1	2	3	4	5	6
18	4	5–1	5–1	4	62	10	10	11–1	10	11–1	10
54	13	14–1	14–1	13							
62	15	16–1	16–1	15							

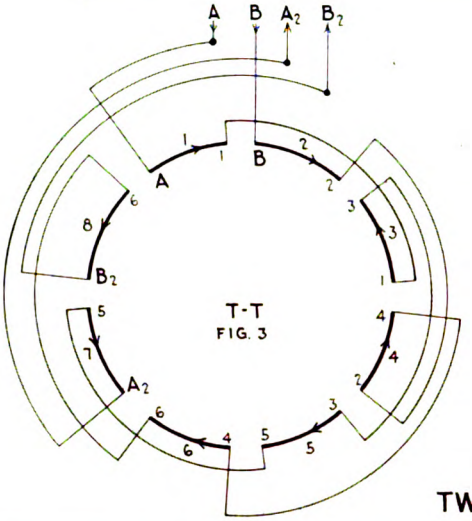
CONNECTIONS FOR ENDS OF GROUPS
OF TWO-POLE, THREE-PHASE MOTORS.
SEE FIG. 2.

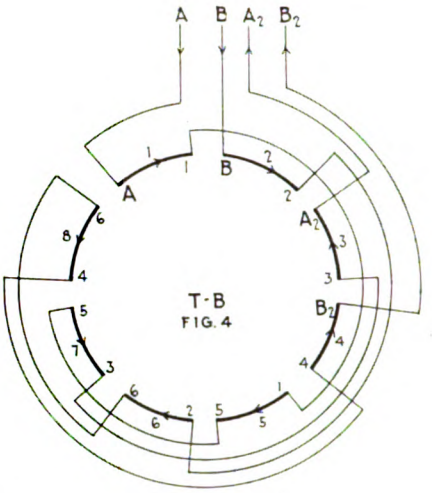
Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Group No.	1		2		3		4		5		6	
	T	B	T	B	T	B	T	B	T	B	T	B
Series Star	A	1	*	2	B	3	*	1	C	2	*	3
2 Parallel Star	A	*	*	C	B	*	*	A	C	*	*	B
Series Delta	A	1	B	2	B	3	C	1	C	2	A	3
2 Parallel Delta	A	C	B	C	B	A	C	A	C	B	A	B

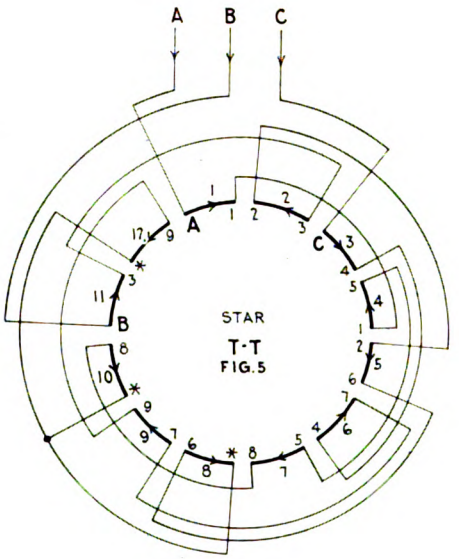
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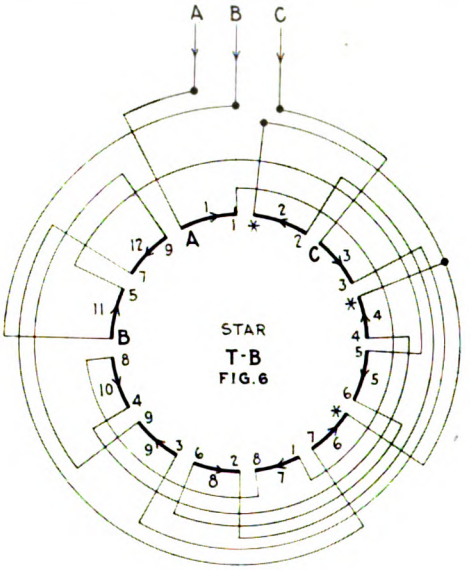
Four-Pole Windings

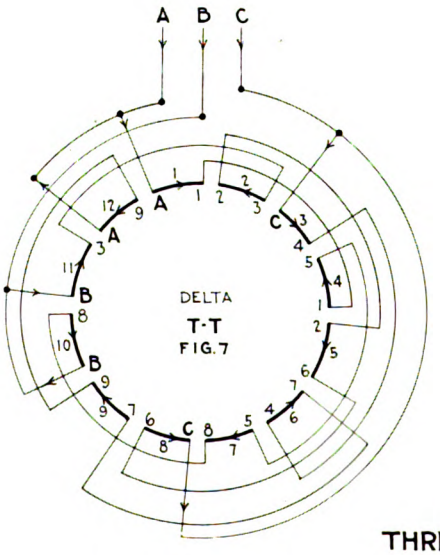


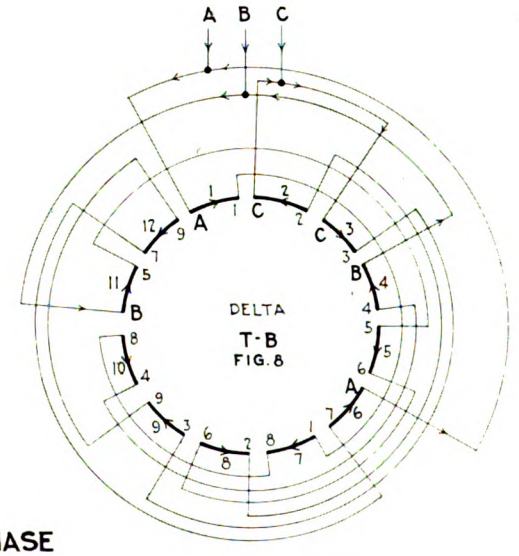


TWO-PHASE









THREE-PHASE

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for the particular winding in question. As it does not appear for the eight-pole two-parallel winding it is disregarded in this case, and the figures given in *Chart G* are followed instead.

However, if this had been a four-parallel winding, leaving all other conditions the same it will be seen by consulting the *Main Table* that a small *k* appears with the letter *G*, as G^k. Therefore, this small *k* must be taken into account when grouping the coils according to *Chart G*. In each group where this small *k* appears one coil must be killed. This means that in groups 4, 5 and 6 a coil must be killed leaving only two coils in each of the groups.

In some cases the charts show a notation such as 3-1. This means that one coil must always be killed in such a group. A case of this kind is shown in *Chart H* in the left-hand table for the winding having 62 coils. The grouping according to this line of figures is as follows: 3, 3-1, 3, 2, 3, and so on. This means that the second group which is designated by 3-1 must be of three coils, one of which is killed.

In a few cases a star or asterisk (*) is shown in the *Main Table*. In this case, in the chart referred to by the letter in the *Main Table*, there are two rows of figures applying to the same number of coils. The second row of figures has at the left-hand end a star. This is the row of figures which must be used when the star appears in the *Main Table*. Where such a case occurs it means that a series connection may be used with this number of coils without killing any coils. However, when a parallel connection is wanted some of the coils must be killed and the method of doing this is indicated by the line in the chart in which the star appears.

As an example take a two-phase, six-pole motor having eighteen coils. For a series connection the *Main Table* has the notation *E*. For a two-parallel connection the notation is *E**. Looking under *Chart E* we see there are two lines for eighteen coils. One of the lines has an asterisk with the 18 as 18*. This is the line to use when making repairs on two-parallel windings.

Although the charts cover most of the cases met in ordinary repair work, it is well to explain how to figure out the unequal coil groupings for any case. The method of doing this will be explained in another article to appear later.

When the coils are already con-

Four-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, CHART C

Top-to-Top

Coils	Group Numbers							
	1	2	3	4	5	6	7	8
12	1	1	2	2	1	1	2	2
36	4	4	5	5	4	4	5	5
54	7-1	6	7	7	6	7-1	7	7
60	7	7	8	8	7	7	8	8
62	8-1	7	8	8	7	8-1	8	8
84	10	10	11	11	10	10	11	11
86	11-1	10	11	11	10	11-1	11	11
90	12-1	11	11	11	11	12-1	11	11
108	13	13	14	14	13	13	14	14
135	16	17-1	17	17	17-1	17-1	17	17
150	19-1	18	19	19	18	19-1	19	19
156	19	19	20	20	19	19	20	20
180	22	22	23	23	22	22	23	23

Top-to-Bottom

12	1	2	2	1	2	1	1	2
36	4	5	5	4	5	4	4	5
54	7-1	7	7	6	7	7-1	6	7
60	7	8	8	7	8	7	7	8
62	8-1	8	8	7	8	8-1	7	8
84	10	11	11	10	11	10	10	11
86	12-1	11	11	11	11	12-1	11	11

THREE-PHASE, CHART D

Top-to-Top

Coils	Group Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	1	2	1	2	1	1	2	1	2	1	2
54	4	5	4	5	4	5	5	4	5	4	5	4
62	6-1	5	5	5	5	5	5	6-1	5	5	5	5
80	6	7	7-1	7	6	7	7	7-1	7	6	7	6
86	7	7	8-1	7	7	7	8-1	7	7	7	7	7
90	7	8	7	8	7	8	8	7	8	7	8	7
104	8	9	9-1	9	8	9	9	9-1	9	8	9	8
128	10	11	11-1	11	10	11	11	11-1	11	10	11	10
135	12-1	11	11	11	12-1	11	11	11	12-1	11	11	11
150	12	13	12	13	12	13	13	12	13	12	13	12
160	14-1	13	13	13	14-1	13	13	13	14-1	13	13	14-1

Top-to-Bottom

18	2	1	2	1	2	1	2	1	2	1	2	1
54	4	5	4	5	4	5	4	5	4	5	4	5
62	6-1	5	5	5	5	5	5	6-1	5	5	5	5
80	6	7	7-1	7	6	7	7-1	7	6	7	6	7
86	7	7	8-1	7	7	7	8-1	7	7	7	7	7
90	7	8	7	8	7	8	7	8	7	8	7	8
104	8	9	9-1	9	8	9	9-1	9	8	9	8	9
128	10	11	11-1	11	10	11	11-1	11	10	11	10	11
135	12-1	11	11	11	12-1	11	11	11	12-1	11	11	11
150	12	13	12	13	12	13	12	13	12	13	12	13
160	14-1	13	13	13	14-1	13	13	13	14-1	13	13	14-1

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

TWO-PHASE

Top-to-Top. See Fig. 3.

Group No.	1		2		3		4		5		6		7		8	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	B	2	3	1	4	2	3	5	4	6	A_2	5	B_2	6
2 Parallel	A	1	B	2	A_2	1	B_2	2	A	5	B	6	A_2	5	B_2	6
4 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Top-to-Bottom. See Fig. 4.

Series	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	5	4	6
2 Parallel	A	1	B	2	A_2	3	B_2	4	1	A_2	2	B_2	3	A	4	B
4 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

THREE-PHASE

Star, Top-to-Top. See Fig. 5.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	2		3	C	4	5	1	2	6	7	4	5	8	*	6	7	9	*	8	B	3	*	9
2 Parallel	A	1	*		3	C	4	*	1	B	6	*	4	A	8	*	6	C	9	*	8	B	3	*	9
4 Parallel	A	*	*		B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Star, Top-to-Bottom. See Fig. 6.

Series	A	1	*		2	C	3	*	4	5	6	*	7	1	8	2	6	3	9	4	8	B	5	7	9
2 Parallel	A	1	*		2	C	3	*	4	5	*	*	7	1	*	2	B	3	*	4	A	B	5	7	C
4 Parallel	A	*	*		B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Delta, Top-to-Top. See Fig. 7.

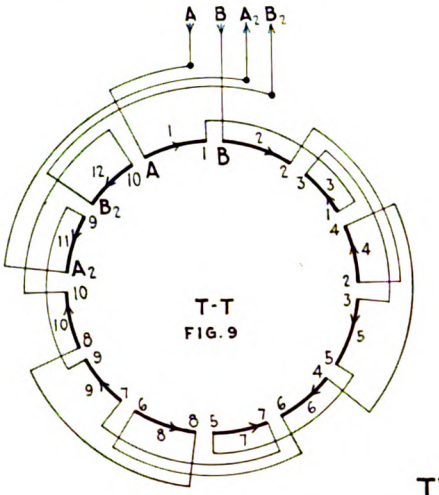
Series	A	1	2		3	C	4	5	1	2	6	7	4	5	8	C	6	7	9	B	8	B	3	A	9
2 Parallel	A	1	C		3	C	4	B	1	B	6	A	4	A	8	C	6	C	9	B	8	B	3	A	9
4 Parallel	A	B	C		B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

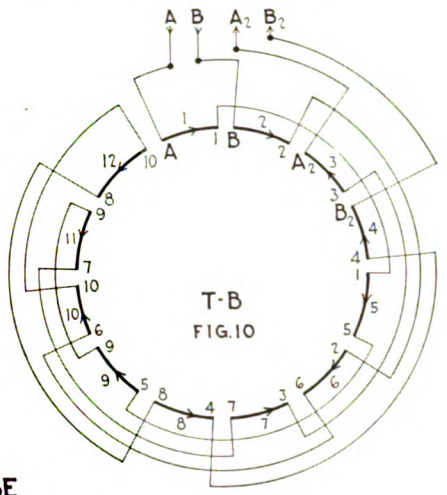
Delta, Top-to-Bottom. See Fig. 8

Series	A	1	C		2	C	3	B	4	5	6	A	7	1	8	2	6	3	9	4	8	B	5	7	9
2 Parallel	A	1	C		2	C	3	B	4	5	C	A	7	1	B	2	B	3	A	4	A	B	5	7	C
4 Parallel	A	B	C		B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A	B	C	A	C

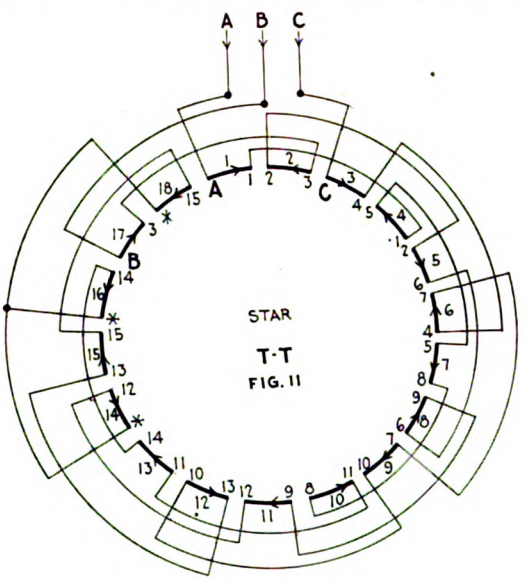
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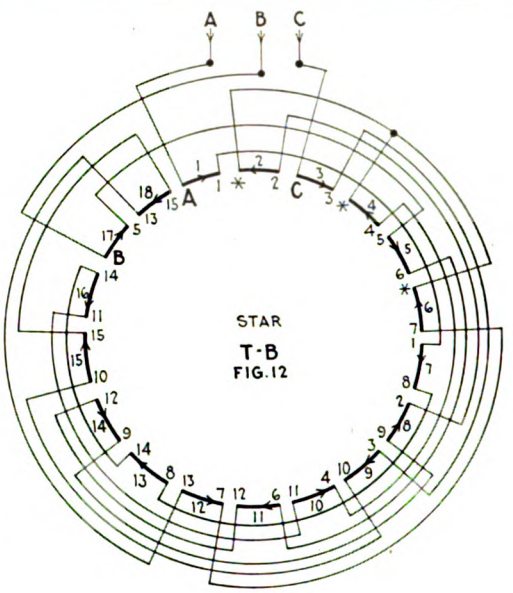
Six-Pole Windings

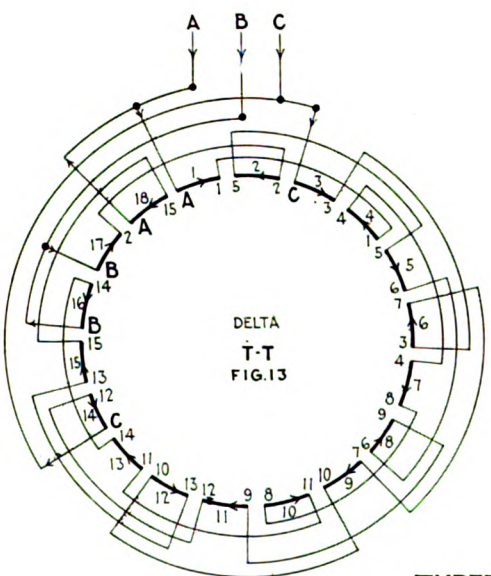


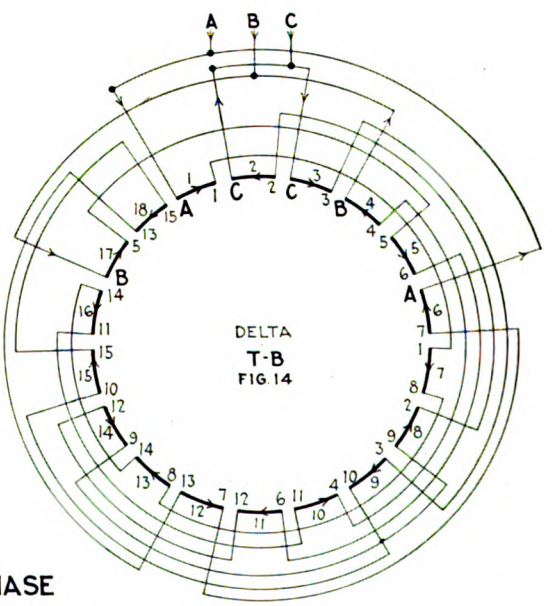


TWO-PHASE









THREE-PHASE

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Six-Pole Windings

These Tables refer to accompanying diagrams marked figures 9 to 14 inclusive and to the discussion on unequal coil grouping.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is indicated by (*).

Two-Phase, Top-to-Top. See Fig. 9.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	B	2	3	1	4	2	3	5	4	6	7	5	8	6	7	9	8	10	A_2	9	B_2	10
2 Parallel	A	1	B	2	3	1	4	2	3	A_2	4	B_2	7	A	8	B	7	9	8	10	A_2	9	B_2	10
3 Parallel	A	1	B	2	A_2	1	B_2	2	A	5	B	6	A_2	5	B_2	6	A	9	B	10	A_2	9	B_2	10
6 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Two-Phase, Top-to-Bottom. See Fig. 10

Series	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10
2 Parallel	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	A_2	6	B_2
3 Parallel	A	1	B	2	A_2	3	B_2	4	1	A_2	2	B_2	3	A	4	B	A	9	B	10
6 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2

Series	7	4	8	5	9	6	10	7	9	8	10									
2 Parallel	7	4	8	5	A_2	6	B_2	7	A	8	B									
3 Parallel	A_2	4	B_2	3	A	4	B	A	9	B	10	A_2	9	B_2	10					
6 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A	B_2	B					

Three-Phase Star, Top-to-Top. See Fig. 11.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	2	3	C	4	5	1	2	6	7	4	5	8	9	6	7	10	11	8	9	12	13	10
2 Parallel	A	1	2	3	C	4	5	1	2	*	7	4	5	*	9	B	7	*	11	A	9	12	13	C
3 Parallel	A	1	*	3	C	4	*	1	B	6	*	4	A	8	*	6	C	10	*	8	B	12	*	10
6 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C

Series	11	14	12	13	15	14	B	3	*	15										
2 Parallel	11	14	12	13	15	14	B	3	*	15										
3 Parallel	A	14	12	C	15	14	B	3	*	15										
6 Parallel	A	*	B	C	*	*	A	B	*	*	C									

Three-Phase Star, Top-to-Bottom. See Fig. 12.

Series	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11
2 Parallel	A	1	*	2	C	3	*	4	5	6	*	7	1	8	2	9	3	10	4	11
3 Parallel	A	1	*	2	C	3	*	4	5	*	*	7	1	*	2	B	3	*	4	A
6 Parallel	A	*	*	B	C	*	*	A	B	*	*	C	A	*	*	B	C	*	*	A

Series	6	12	7	13	8	14	9	12	10	15	11	14	B	5	13	15				
2 Parallel	6	*	7	13	8	*	9	B	10	*	11	A	B	5	13	C				
3 Parallel	B	12	7	C	A	14	*	12	C	15	*	14	B	5	*	15				
6 Parallel	B	*	*	C	A	*	*	B	C	*	*	A	B	*	*	C				

Three-Phase Delta, Top-to-Top. See Fig. 13.

Series	A	1	5	2	C	3	4	1	5	6	7	3	4	8	9	6	7	10	11	8
2 Parallel	A	1	5	2	C	3	4	1	5	C	7	3	4	B	9	B	7	A	11	A
3 Parallel	A	1	C	2	C	3	B	1	B	6	A	3	A	8	C	6	C	10	B	8
6 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A

Series	9	12	13	10	11	14	C	12	13	15	B	14	B	2	A	15				
2 Parallel	9	12	13	C	11	14	C	12	13	15	B	14	B	2	A	15				
3 Parallel	B	12	A	10	A	14	C	12	C	15	B	14	B	2	A	15				
6 Parallel	B	C	A	B	C	A	B	C	B	C	A	B	A	B	C	A	C			

Three-Phase Delta, Top-to-Bottom See Fig. 14.

Series	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11
2 Parallel	A	1	C	2	C	3	B	4	5	6	A	7	1	8	2	9	3	10	4	11
3 Parallel	A	1	C	2	C	3	B	4	5	C	A	7	1	B	2	B	3	A	4	A
6 Parallel	A	B	C	B	C	A	B	A	B	C	A	C	A	B	C	B	C	A	B	A

Series	6	12	7	13	8	14	9	12	10	15	11	14	B	5	13	15				
2 Parallel	6	C	7	13	8	B	9	B	10	A	11	A	B	5	13	C				
3 Parallel	B	12	7	C	A	14	C	12	C	15	B	14	B	5	A	15				
6 Parallel	B	C	A	B	C	A	B	C	B	C	A	B	A	B	C	A	C			

UNEQUAL COIL GROUPING

TWO-PHASE, CHART E
Top-to-Top Connections

Coils	Group Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	2	1	1	2	2	1	1	2	2	1	1
*18	2-1	1	2	2	1	1	1	2-1	2	2	1	1
54	4	4	5	5	4	4	5	5	4	4	5	5
*54	5-1	4	5	5	4	4	4	5-1	5	5	4	4
62	6-1	5	5	5	5	5	5	6-1	5	5	5	5
80	6	7	7	6	7	7k	6	7	7	6	7k	7
86	8-1	7	7	7	7	7	7	8-1	7	7	7	7
90	7	7	8	8	7	7	8	8	7	7	8	8
*90	8-1	7	8	8	7	7	7	8-1	8	8	7	7
104	8	9	9	9k	9	8	8	9	9k	9	9	8
128	10	11	11	11k	11	10	10	11	11k	11	11	10
135	12k	11	11	11	12-1	11	11	12k	11	11	11	11
150	12	12	13	13	12	12	13	13	12	12	13	13
*150	13-1	12	13	13	12	12	12	13-1	13	13	12	12
160	14k	13	13	14k	13	13	14k	13	13	14k	13	13

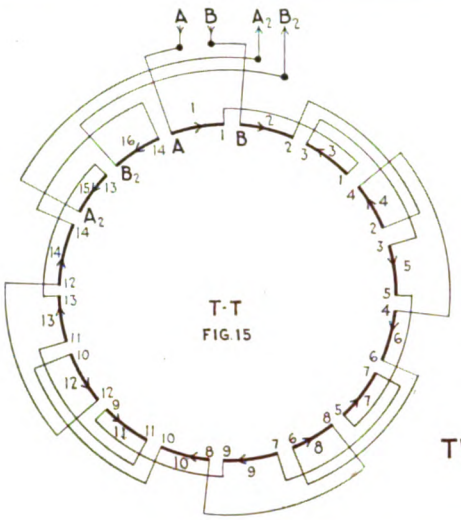
†These groupings are not for top-to-bottom connection.
kA coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.
*Use this line where an asterisk (*) appears in the Main Table

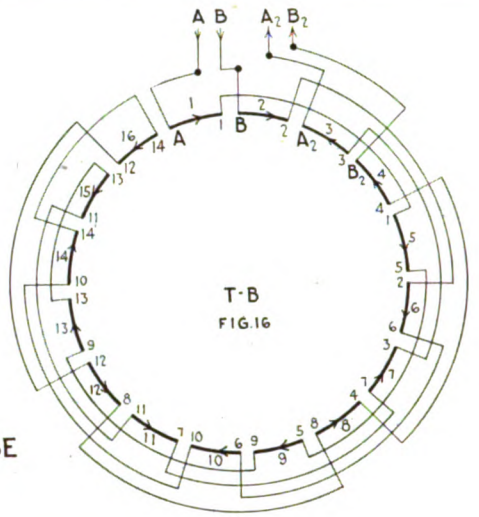
THREE-PHASE, CHART F
Top-to-Top and Top-to-Bottom

Coils	Group Numbers																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
24	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1
48	2	3	3	3	3	2	3	2	3	2	3	3	3	3	2	3	2	3
60	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3
62	4	3	3	3	3	4	4-1	4	3	4	3	3	3	3	4	3	4	4-1
80	5	4	4	4	4	5	5-1	5	4	4	4	4	4	4	5	4	5	5-1
84	4	5	5	5	5	4	5	4	5	4	5	5	5	5	4	5	4	5
86	4	5	5	5	5	5-1	5	4	5	4	5	5	5	5	4	5	5-1	5
96	6	5	5	5	5	6	5	6	5	6	5	5	5	5	6	5	6	5
104	5	6	6	6	6	6-1	6	5	6	5	6	6	6	5	6	6	6-1	6
120	6	7	7	7	7	6	7	6	7	6	7	7	7	7	6	7	6	7
128	7	7	7	7	7	8-1	7	7	7	7	7	7	7	7	7	8-1	7	7
†135	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7	8	7
†135*	8-1	8	8	7	7	7	8	8-1	8	7	7	7	8	8	8-1	7	7	7
150	9	8	8	8	8	9	8	9	8	9	8	8	8	8	9	8	9	8
156	8	9	9	9	9	8	9	8	9	8	9	9	9	9	8	9	8	9
†160	9-1	9	9	9	9	9k	9	8	9	9k	9	9	9	9	8	9	9k	9
*160	9-1	9	9	9	9	9-1	9	8	9	9-1	9	9	9	9	8	9	9-1	9
168	10	9	9	9	9	10	9	10	9	10	9	9	9	9	10	9	10	9
240	14	13	13	13	13	14	13	14	13	14	13	13	13	13	14	13	14	13

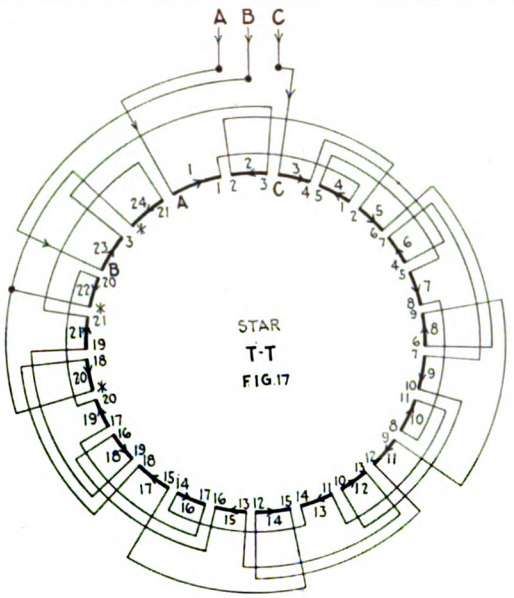
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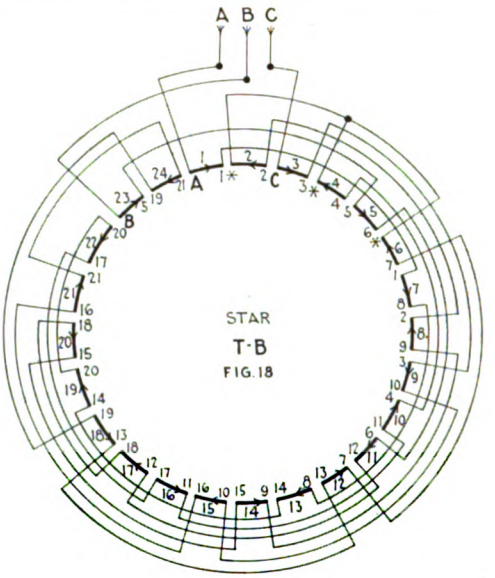
Eight-Pole Windings

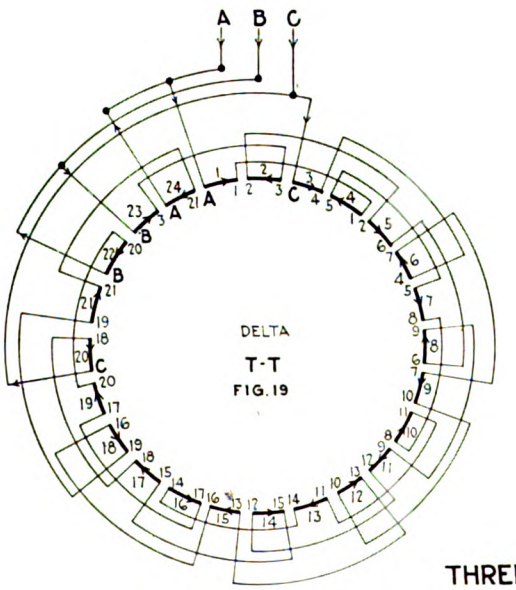


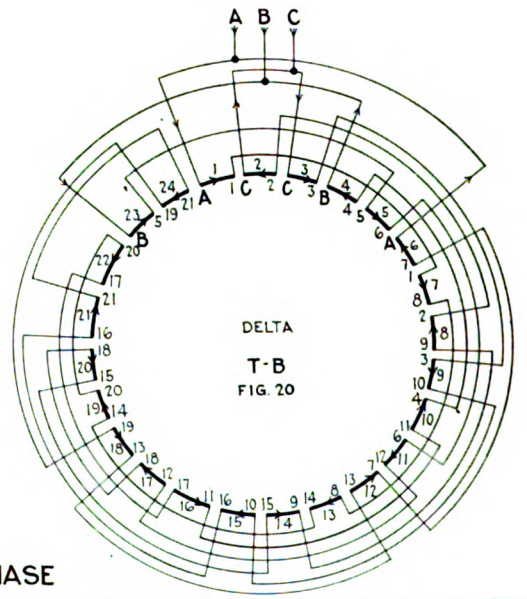


TWO-PHASE









THREE-PHASE

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nected in groups of the proper number, the next step is to connect these groups together in the right relation. The diagrams and tables shown will enable a winder to make any kind of connection that is possible, either series or parallel, for two or three phases and for two to twenty-four poles.

It will be noticed that the diagrams show only the series connections for any winding. The connecting tables, however, corresponding to each one of these diagrams, tell how to make the change from the series to the parallel windings. The diagrams, it will be noticed, give both top-to-top and top-to-bottom connections for windings having two to fourteen poles. For sixteen to twenty-four poles only the top-to-top connection is given. For the three-phase machines both delta and star diagrams are shown.

How the Diagrams and Connection Tables are Used

In order to understand the use of the diagrams and connecting tables let us consider a four-pole, two-phase motor connected top-to-top. The diagram for this connection is shown in Fig. 3 and the corresponding table is shown on the page opposite this figure. In this diagram there are eight pole-phase groups represented by the eight sectors of the innermost circle. Each of these groups has a number as indicated by the figures at the center of the groups. At the beginning and the end of each group are other numbers. These indicate the numbers of the jumpers. For instance, in group 1 the figures *A* and *1* appear. This indicates that the *A* lead (one of the line leads) connects to the top of group 1. Throughout the diagrams, the top lead is the left-hand end of each group. Likewise the bottom of group 1 is connected by jumper No. 1 to another group. This happens to be group No. 3, as may be seen from the diagram.

In the connecting table, these figures which indicate the jumper numbers, are put down. As will be seen from the table the numbers for the jumpers attached to group 1 are *A* and *1*, to group 2 are *B* and *2*, to group 3 are *3* and *1* and so on. Likewise, the other connections besides the series are shown in this same table. The figures are changed only where it is necessary to change the location of jumpers on the winding.

It will be seen then, that if we have a four-pole, two-phase series motor connected top-to-top and we want to reconnect it in two-parallel top-to-top, we must make changes only where the second line in the table differs from the first line. There is no change until we reach group 3 where it is seen that the top of the group instead of connecting to jumper No. 3 as before, now connects to A_2 or the other side of the line on the *A* phase. Likewise, changes are made in the jumpers going to the top leads of groups 4, 5 and 6. The tops of these groups were originally connected to jumpers 3 and 4. Therefore, to make the change, jumpers 3 and 4 are cut in half and the top of group 3 is connected to the original A_2 lead. Likewise the top of group 4 is connected to the original B_2 lead. The other end of No. 3 jumper, which is attached to the top of group 5, is connected to the *A* lead, and the remaining end of No. 4 jumper, which is connected to the top of group 6, is now connected to the *B* lead.

Thus the table shows at a glance where a change has to be made when reconnecting.

When using the tables to connect a rewound motor a set of tags should be used. These tags are numbered according to the connections required by the connecting table. For instance, for a two-parallel, four-pole, 2-phase, top-to-top connection there would be two tags each for the following figures and letters: A_2, *A*, B_2, *B*, *1*, *2*, *5*, and *6*. After these tags are made they may be put on in the following manner. Face the connection end of the stator and call the left-hand lead of a stubbed-up group the top lead of group No. 1.

Eight-Pole Two-Phase Windings

UNEQUAL COIL GROUPING

Top-to-Top. Chart G

Coils	Group Numbers															
	1 2		3 4		5 6		7 8		9 10		11 12		13 14		15 16	
24	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2
36	3[k]	2	2	2	2	3[k]	2	2	3[k]	2	2	2	2	3[k]	2	2
54	4[k]	3	4–1	3	3	4[k]	3	3	4[k]	3	3	4–1	3	4[k]	3	3
60	3	4[k]	4	4	4[k]	3	4	4	3	4[k]	4	4	4[k]	3	4	4
62	3	4[k]	4	4	4[k]	4–1	4	4	4–1	4[k]	4	4	4[k]	3	4	4
72	4	4	5	5	4	4	5	5	4	4	5	5	4	4	5	5
84	6[k]	5	5	5	5	6[k]	5	5	6[k]	5	5	5	5	6[k]	5	5
86	6[k]	5	6–1	5	5	6[k]	5	5	6[k]	5	5	6–1	5	6[k]	5	5
90	6–1	5	6	6	5	5	6	6	5	6–1	6	6	5	5	6	6
104	6	6	7	7	6	6	7	7	6	6	7	7	6	6	7	7
108	6	7[k]	7	7	7[k]	6	7	7	6	7[k]	7	7	7[k]	6	7	7
120	7	7	8	8	7	7	8	8	7	7	8	8	7	7	8	8
135	9[k]	8	8	8	9–1	9[k]	8	8	9[k]	9–1	8	8	9–1	9[k]	8	8
150	10[k]	9	10–1	9	9	10[k]	9	9	10[k]	9	9	10–1	9	10[k]	9	9
156	9	10[k]	10	10	10[k]	9	10	10	9	10[k]	10	10	10[k]	9	10	10
168	10	10	11	11	10	10	11	11	10	10	11	11	10	10	11	11
180	12[k]	11	11	11	11	12[k]	11	11	12[k]	11	11	11	11	12[k]	11	11
216	14	14	13	13	14	14	13	13	14	14	13	13	14	14	13	13

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

Top-to-Top. See Fig. 15.

Group No.	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16	
	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
Series	A	1	B	2	3	1	4	2	3	5	4	6	7	5	8	6	7	9	8	10	11	9	12	10	11	13	12	14	A_2	13	B_2	14
2 Parallel	A	1	B	2	3	1	4	2	3	5	4	6	A_2	5	B_2	6	A	9	B	10	11	9	12	10	11	13	12	14	A_2	13	B_2	14
4 Parallel	A	1	B	2	A_2	1	B_2	2	A	5	B	6	A_2	5	B_2	6	A	9	B	10	A_2	9	B_2	10	A	13	B	14	A_2	13	B_2	14
8 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

Top-to-Bottom. See Fig. 16.

Series	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	13	10	14	11	13	12	14
2 Parallel	A	1	B	2	A_2	3	B_2	4	1	5	2	6	3	7	4	8	5	9	6	10	7	11	8	12	9	A_2	10	B_2	11	A	12	B
4 Parallel	A	1	B	2	A_2	3	B_2	4	1	A_2	2	B_2	3	A	4	B	A	9	B	10	A_2	11	B_2	12	9	A_2	10	B_2	11	A	12	B
8 Parallel	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B	A	A_2	B	B_2	A_2	A	B_2	B

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On this lead put an *A* tag. Then on the bottom or right-hand lead of the same group put a No. 1 tag. The next group to the right is called No. 2 and on this group are placed the *B* tag and the 2 tag. Then follow this out according to the figures and letters in the connecting table. After all these tags are on, then put jumpers between the group ends which have similar numbers, the two tags which have No. 1 on them, the two tags which have No. 2 on them, etc. Connect all the tags with *A* to one line lead and with A_2 to the other line in the same phase. Likewise connect the B phase to the tags which have *B* and B_2.

When using the top-to-bottom connections the same scheme is carried out. In changing from series to two-parallel the short jumper is cut.

By Following the Tables it Is Easy to Change from a Star to a Delta Connection

If it is desired to change from a star to a delta connection or the reverse, simply follow the tables. As an example, on the series star connection for a four-pole motor, connected top-to-bottom, a star (*) is shown for the top lead in groups 2, 4 and 6. (*Continued on page 152.*)

Eight-Pole Three-Phase Windings

UNEQUAL COIL GROUPING—CHART H

Top-to-Top

Coils	Group Numbers 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
36	2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1
54	3 2 2 2 3 2 2 2 3 2 2 2 3 2 2 2 3 2 2 2 3 2 2 2
60	3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2 3 2
62	3 3-1 3 2 3 2 3 2 3 2 3 3-1 3 2 3 2 3 2 3 2 3 2 3 2
80	4 3 3 3 4 3 3 3 4 4-1 3 3 4 3 3 3 4 3 3 4 3 3 4-1
84	4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3
86	4 4-1 4 3 4 3 4 3 4 3 4 4-1 4 3 4 3 4 3 4 3 4 3 4 3
90	3 4 4^k 5 3 4 4^k 4 3 4 4^k 3 4 4^k 4 3 4 4^k 4 3 4 4^k 4 3 4 4^k 4
104	5^k 4 4 4 5^k 4 4 4 5^k 4 5-1 4 5^k 4 4 4 5^k 4 4 4 5^k 4 4 5-1
108	5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4 5 4
128	6^k 5 5 5 6^k 5 5 5 6^k 5 6-1 5 6^k 5 5 5 6^k 5 5 5 6^k 5 5 6-1
135	6 6-1 6 5 6 5 6 5 6 6-1 6 5 6 5 6 5 6 6-1 6 5 6 5 6 5
150	7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6
156	7 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6 7 6
160	7 7-1 7 6 7 7-1 7 6 7 7-1 7 6 7 6 7 6 7 7-1 7 6 7 6 7 6
180	8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7

Top-to-Bottom

Coils	Group Numbers 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
36	2 1 2 1 2 1 1 2 1 2 1 2 2 1 2 1 2 1 1 2 1 1 2 1
54	3 2 2 2 3 2 2 2 3 2 2 2 3 2 2 2 3 2 2 3 2 2 3 2
60	3 2 3 2 3 2 2 3 2 3 2 3 3 2 3 3 2 3 2 3 2 2 3 2
62	3 3 1 3 2 3 2 2 3 2 3 2 3 3-1 3 2 3 2 2 3 2 3 2 3
80	4 3 3 3 4 3 3 3 4 3 3 4 4 3 3 4 3 3 3 4 3 3 4 3
84	4 3 4 3 4 3 3 4 3 4 3 4 4 3 4 4 3 4 3 4 3 3 4 3
86	4 4-1 4 3 4 3 3 4 3 4 3 4 4-1 4 3 4 3 3 4 3 4 3 4
90	3 4^k 4 4 3 4^k 4 4 3 4^k 4 4 3 4^k 4 4 3 4^k 4 4 3 4^k 4 4 3 4^k 4
104	5^k 4 4 4 5^k 4 4 4 5^k 4 5-1 4 5^k 4 4 4 5^k 4 4 4 5^k 4 4 5-1
108	5 4 5 4 5 4 4 5 4 5 4 5 5 4 5 4 5 4 5 4 5 4 5 4
128	6^k 5 5 5 6^k 5 5 5 6^k 5 6-1 5 6^k 5 5 5 6^k 5 5 5 6^k 5 5 6-1
135	6 5 6 6-1 6 5 5 6 5 6 6-1 6 5 6 5 6 6-1 6 5 6 5 6 5
150	7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6 6 7^k 6 6
156	7 6 7 6 7 6 6 7 6 7 6 7 7 6 7 6 7 6 7 6 7 6 7 6
160	7 7-1 7 6 7 7-1 6 7 6 7 7-1 7 6 7 6 7 6 7 7-1 7 6 7 6 7
180	8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7

^{k} A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

Star, Top-to-Top. See Fig. 17.

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B	T B
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	* 18	19 21	* 20	B 3	* 21
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	* 6	7 10	* 8	B 12	* 10	A 14	15 12	C 16	17 14	15 18	19 16	17 20	* 18	19 21	* 20	B 3	* 21
4 Parallel	A 1	* 3	C 4	* 1	B 6	* 4	A 8	* 6	C 10	* 8	B 12	* 10	A 14	* 12	C 16	* 14	B 18	* 16	A 20	* 18	C 21	* 20	B 3	* 21
8 Parallel	A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* * C

Star, Top-to-Bottom. See Fig. 18.

Series	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19	14 20	15 18	16 21	17 20	B 5	19 21
2 Parallel	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 *	13 19	14 *	15 B	16 *	17 A	B 5	19 C
4 Parallel	A 1	* 2	C 3	* 4	5 *	* 7	1 *	2 B	3 *	4 A	B 12	7 C	A 14	* 15	C 16	* 17	12 *	* 19	14 *	15 B	16 *	17 A	B 5	19 C
8 Parallel	A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* * C

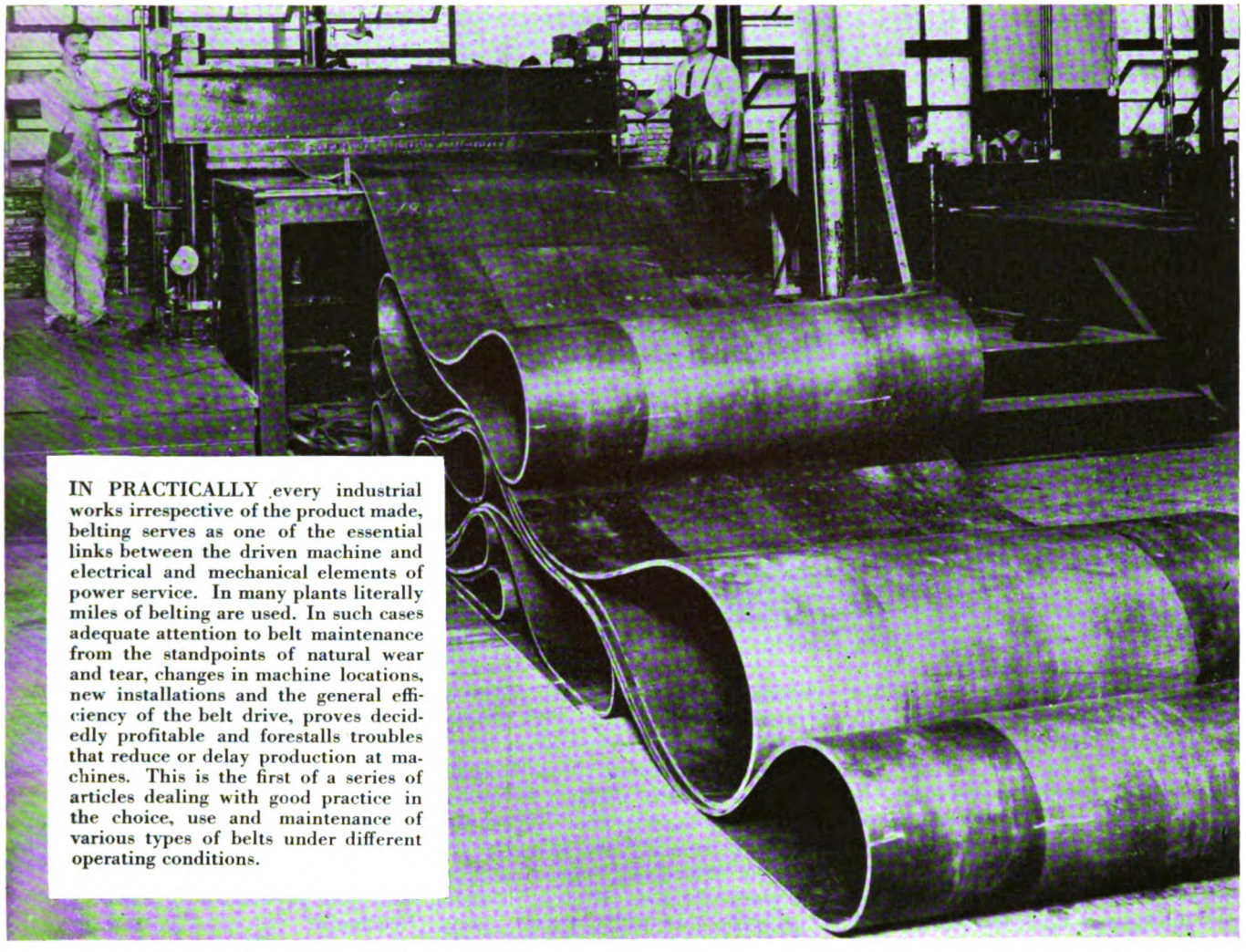
Delta, Top-to-Top. See Fig. 19.

Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	C 18	19 21	B 20	B 3	A 21
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	C 6	7 10	B 8	B 12	A 10	A 14	15 12	C 16	17 14	15 18	19 16	17 20	C 18	19 21	B 20	B 3	A 21
4 Parallel	A 1	C 3	C 4	B 1	B 6	A 4	A 8	C 6	C 10	B 8	B 12	A 10	A 14	C 12	C 16	B 14	B 18	A 16	A 20	C 18	C 21	B 20	B 3	A 21
8 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

Delta, Top-to-Bottom. See Fig. 20

Series	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19	14 20	15 18	16 21	17 20	B 5	19 21
2 Parallel	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 C	13 19	14 B	15 B	16 A	17 A	B 5	19 C
4 Parallel	A 1	C 2	C 3	B 4	5 C	A 7	1 B	2 B	3 A	4 A	B 12	7 C	A 14	C 15	C 16	B 17	12 C	A 19	14 B	15 B	16 A	17 A	B 5	19 C
8 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

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IN PRACTICALLY every industrial works irrespective of the product made, belting serves as one of the essential links between the driven machine and electrical and mechanical elements of power service. In many plants literally miles of belting are used. In such cases adequate attention to belt maintenance from the standpoints of natural wear and tear, changes in machine locations, new installations and the general efficiency of the belt drive, proves decidedly profitable and forestalls troubles that reduce or delay production at machines. This is the first of a series of articles dealing with good practice in the choice, use and maintenance of various types of belts under different operating conditions.

One of the most important steps in the manufacture of a belt—the cementing of the laps and plys. This is a 60-in. three-ply main drive belt being made on an 86-in. belt press. Unless this operation is done properly a belt will soon begin to open at the laps.

Points of Construction And Other Things About

Fabric-Base and Leather Belts

On Which Good Service from the Pulley and Belt as a Unit Depend

By FRANK E. GOODING

Associate Editor, Industrial Engineer

RECENTLY a large 40-inch double leather belt was removed from service after 34 years of operation in an industrial plant on a water wheel drive that operates 24-hr. a day. Although the machine which it drove for these years was worn out, the belt was cut up and is still giving service on other machines. During this time there is no record of the belt having given any serious trouble. Who would question but that this was an economical belt installation? Doubtless many other belts just as good as this one were put on at the same time and lasted only a few years. It seems, therefore, that belt trouble is not always the fault of the belt. Much depends upon the proper choice of a belt suitable for the work it is to do. As a foundation for making the choice this article will take up the essential details of construction and operation of various types of belts. Other articles to follow will cover the selection, ordering specifications, inspection, maintenance, and reclamation of belts.

THE DIFFERENT TYPES OF BELTS

There are two general classes of belts—those made of cotton as a base and those made of leather. Belts with cotton fabric as a base are divided into three general classes: (1) Solid-woven belts; (2) canvas belts, and (3) rubber and Balata belts. Solid-woven cotton belts are woven to any required thickness as a solid belt. The various thicknesses are designated by "plys" but it is not a standardized dimension. One manufacturer, for example,

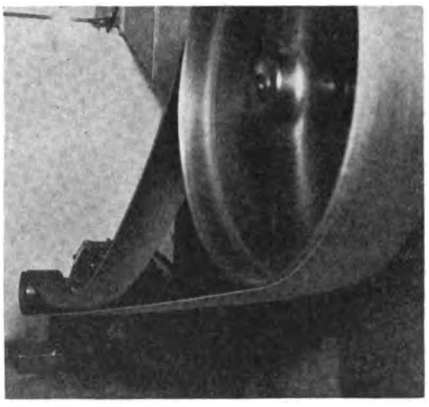
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makes single, double and triple ply, solid-woven belts which it is claimed correspond to the single, double and triple leather belts.

Canvas belts are made by wrapping or folding several thicknesses of canvas and stitching them together. In some belts the stitches are covered with another layer or ply of canvas and again lightly stitched. Cotton belts, either solid-woven or stitched, are practically always impregnated with some special preparation which renders the belt waterproof and in some cases protects it from fumes, steam or other deteriorating conditions. In addition, this preparation lubricates the working parts of the belt so that the fabric is more pliable and causes less friction in the repeated bending and straightening of a belt in operation.

Rubber belts are built up by either folding or wrapping various thicknesses or plys of canvas and cementing them together with a rubber gum. An additional coating of rubber is placed on the outside and the entire belt vulcanized. Here the thicknesses of rubber between the layers of canvas take the place of the stitching, although in some cases rubber belts are also stitched. The thickness of the outer coating of rubber depends upon the work which the belt is called upon to do. For example, conveyor belts generally have a thick coating of rubber to take the wear of the material carried and also to protect the belt from dampness. Power transmission belts generally have a thin or friction coat unless they are to be used in wet places, and then the coating is heavier.

Balata belt differs from rubber belt in that Balata gum is used instead of rubber gum and that the method of preparation and arrangement of the fabric base and the impregnation with gum are different. Practically, the fabric gives the belt strength while the rubber or other impregnation cements it together and also gives it tractive as well as a good wearing surface. Rubber and canvas belts are made from 4 to 12 plys in thickness, depending upon the work which is required of them.



One of the most severe driving problems exists where there is a wide variation between the diameters of the driving and driven pulleys, as here.

Here a 9-in., double leather belt on a 10-in. motor pulley drives a 36-in. blower pulley set at 9-ft. centers. The belt travels at 2,356 ft. per min. and operates 24 hrs. per day. This belt is operated with 22 in. of slack due to the special treatment which makes it cling to the surface of the pulley and gives it sufficient adhesion without high tension.

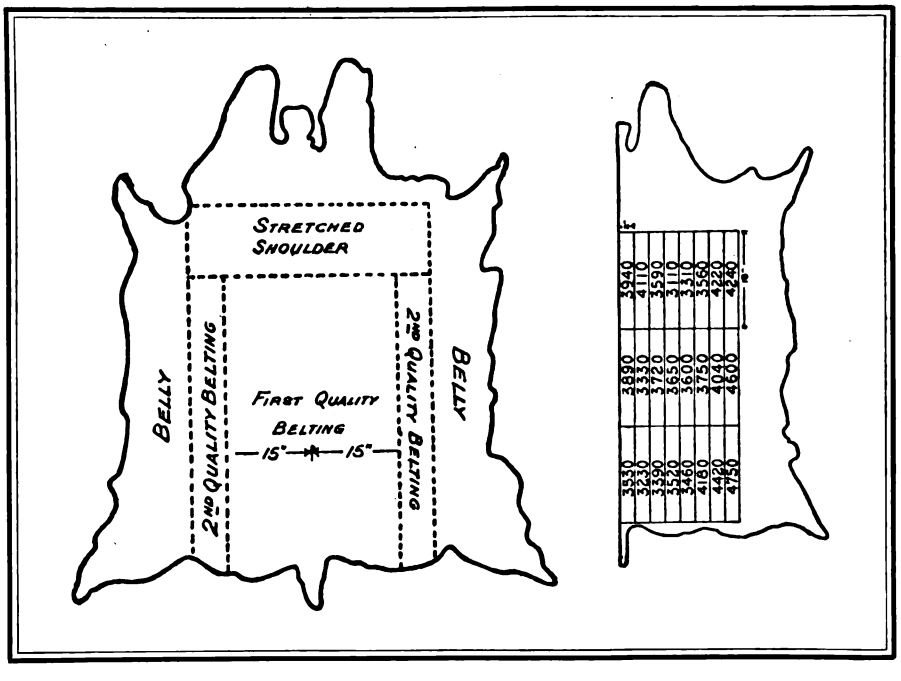
The Types of Leather Belting

Leather belts of the best quality are made from oak-tanned steer hides. Only a small portion of the hide is used in making the best belts, as shown in the accompanying drawing. This is a piece about 15 to 18 in. on each side of the backbone and from the shoulders to the base of the tail. Even this section of the hide is not uniform in all animals, as the texture of the skin varies with each individual hide, but it is the most satisfactory for making belts. Also, the strength, pliability and elasticity varies, depending upon the section of the hide from which it is cut. The tensile strength per square inch of leather cut from different sections of hides which are used for belt purposes is also shown in the smaller drawing accompanying this article.

Practically all belt manufacturers make a variety of grades of belting. The difference in these grades is due to the grading of the hide before it is cut and also to the part of the hide which is used in the belt. These various grades sell at different prices and are suitable for different purposes. Variations in the price of belts of corresponding grades purchased from different manufacturers are due to one or both of the following reasons: (1) Variation in grade of stock; (2) variation in standards of manufacturing processes.

To know what makes a good leather belt it is necessary to have some knowledge of the method of manufacture and the effect of the different production processes on the leather.

After the hide is received from the tannery the section to be used for belting is first cut out. This section then is scoured or washed. In this operation the tannery dirt and any other foreign ingredients are washed out. The hide is then ready to go to be "fleshed" where



These sketches show the section of a hide which may be used for making first- and second-grade leather belts and the tensile strength of the different portions.

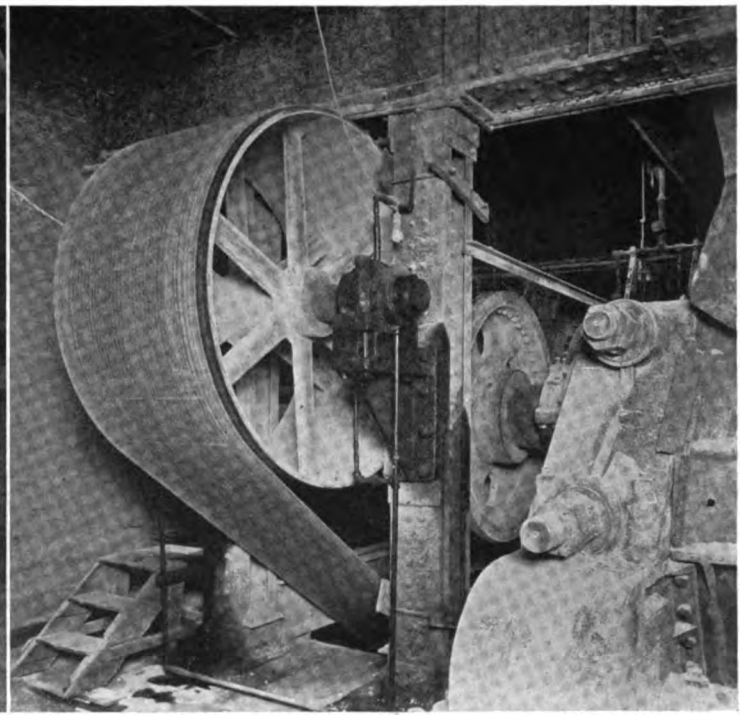
A section of the hide taken from a steer extending about 15 in. on each side of the backbone and about 48 in. in length is used by belt manufacturers to get first-grade belting. A narrow strip on each side is used in second-quality belting as is also a section of shoulder as indicated here. Although the portion of the hide next to the belly is the strongest, it does not make the best belts because it lacks other essential qualities requisite in good belts, as described in this article. These drawings were devised by R. E. Moore, chief engineer, Charles A. Schieren Co., New York, N. Y. Standard Government specifications state that belt must be manufactured from this section of hide.

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An example of a belt-punishing drive in the cement industry.

This belt is made with two plys of leather with a ply of rawhide between. This gives it great strength with almost absolute freedom of stretch. Here it is shown driving a pulverizing machine where the belt runs quarter-turn and is sharply bent over an idler.



A heavy rubber belt on a stone crusher, another severe belt-punishing drive due to the shock loads.

any surplus or loose flesh which is left on the hide by the tanners is removed. Too much must not be shaved off as more than 60 per cent of the strength of the leather is in the inside half of the thickness.

After next passing through the "setting out" machine to smooth out the leather, it is then ready for "currying," which puts back the natural animal oils taken out in the tanning and scouring processes. This operation is of great importance in establishing the life and pliability of the belt.

The sections of hide are then stretched until dry. Over-stretching affects the life and under-stretching causes difficulty in operation. It is now ready to be cut into strips and graded as to weight and thickness and to be joined together to make a uniform belt. The ends are next scarfed and pointed, and then cemented together under pressure. Unless the pieces are properly joined they are likely to come apart and cause trouble. Leather belts may be made waterproof by using special cement at the joints and impregnating the leather when manufactured. Leather belting ordinarily is made in single, double and triple ply. Most manufacturers make three weights of each of these: medium, regular and heavy. Single ply belting is made in all grades; double and triple ply is generally made only from the better grades of leather. One make of belt has a thickness of rawhide between two thicknesses of leather which enables it to stand up under heavy service, as rawhide is about three times as strong as leather belt and has little stretch. For light duty round- and V-belts are used extensively. Some V-belts are of solid leather while others are built up by riveting short pieces of leather together. All of these, however, are used only for comparatively light work.

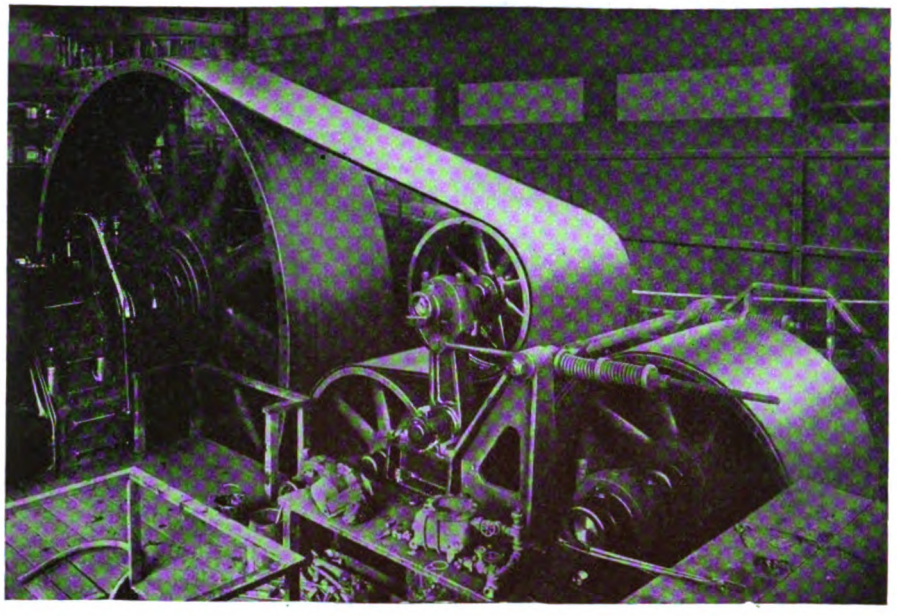
Characteristics of Fabric Belts

Unimpregnated canvas belts or solid-woven belts are not used to any great extent in industry, as they will deteriorate quite rapidly if they become wet or oil soaked. When they are impregnated to withstand moisture, oil and other outside influences, care must be taken to see that they are not too heavily saturated so that they become stiff or lose their tractive effect. Manufacturers of these belts each have their own methods of impregnation and recommend that, if the belt dries out, their own belt dressing be applied.

A wide fluctuation is found among different makes of woven belt in the tractive value. Some rank very low while others rank higher when used up to their rated power. However, when they once reach the rating the tractive effort falls off quite rapidly at increased load. This characteristic is common to most all types of fabric belts. For this reason they are not used where they are subject to heavy overloading unless the capacity is increased correspondingly by using a larger belt.

Another characteristic of all belts with fabric base—this includes rubber and similar types of belts—is that stretch due to contraction of fibers comes out of the belt within the first 24 or 48 hours of service if not used at too high tension. Also during this same period the tractive value of the belt is at its highest. However, as stated before, such a wide variation exists in the quality of different types of these belts that it is difficult to make any general statement about them as a class. Those with a low coefficient of friction can be used only on machines where small power is transmitted. They are very adaptable to high-speed operation, however, and where the combination of low power and high speed exists, can be used to their best advantage. The cheaper types of these belts are frequently used around machines or other places where they quickly become soaked with oil, which spoils rubber and rapidly decreases the value of leather belting unless treated and made oil proof. When cheap fabric belts become oil soaked

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This particular belt operates under severe service conditions with short sharp turns as the belt winds around the four pulleys. This illustrates one method of getting high tension and a contact of over 180 deg. on the pulleys.

and begin to deteriorate they can be thrown away as soon as they become useless for further service without any great loss. Leather belts can often be reclaimed.

Solid woven belts are frequently used as endless belts, although they must be made endless at the factory, as it is not feasible to make a joint in the shop which is smooth and gives the service which is ordinarily demanded of an endless belt. These belts are of very even texture and frequently are used to drive the spindle of internal grinders where a belt of uneven texture or with an uneven joint would affect the work. All kinds of fabric base belts are frequently used for conveyors with good success except that they cannot be used in handling hot materials or those with sharp cutting edges. Usually these belts are not recommended to be used with wet material, although, in one case, for instance, a special impregnated solid-woven conveyor belt handling a wet mixture has stood up well. Overnight the mixture would dry on the belt which had been used previously so that it was always necessary to spend an hour or two to clean up the belt. Since this solid-woven impregnated cotton belt was installed the working of the fabric, as it passes over the pulley, cracks the hardened material and in just a few moments it cleans itself. It may be worth adding that the solid-woven belts of the present day are much different from those which were brought out a few years ago. Among the disadvantages of this belt are that ordinarily a belt cannot be cut down to a narrower width, nor will it stand for continuous shifting, as on planer belts. This latter difficulty can be overcome to a large extent by using roller shifters.

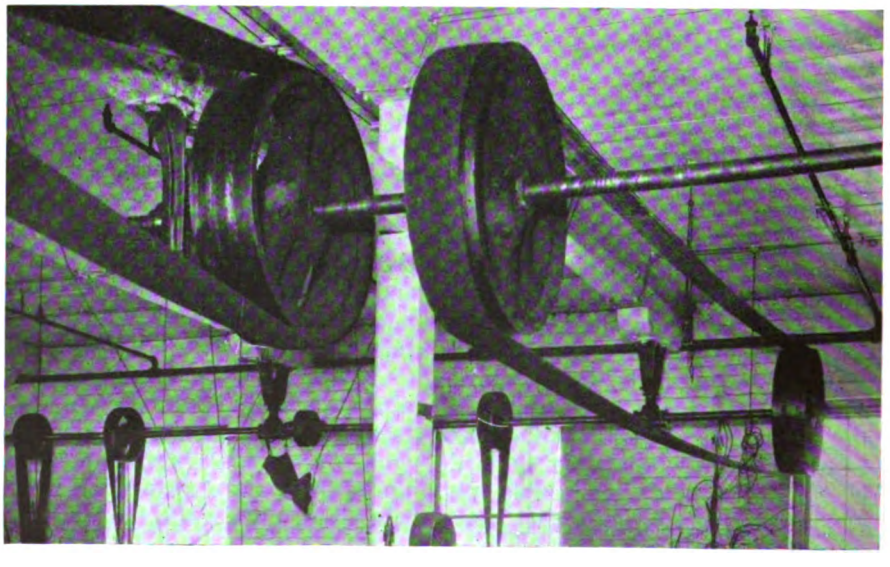
The principal advantage of stitched belts is that they are cheaper in first cost while the main disadvantage is that the stitching decreases the pliability. Many of the belt dressings that are used to impregnate stiff canvas stitched belting to render it waterproof or to give it a greater tractive value increase this stiffness. Due to its low first cost, canvas stitched belting has a wide market where the service is temporary. Like other fabric belting, this does not stand excessive shifting.

Rubber covered belting has good tractive effect up to its rated capacity but care must be taken to see that it does not slip excessively, as to do so will loosen the layer of rubber which holds the canvas plies together. Whenever air gets in between the plies or under the rubber coating, it is compressed as it passes over the pulley and often forces the plies apart for the full length of the belt, if not taken care of at once. Rubber belt withstands moisture well but it cannot be used where it is likely to come in contact with mineral oil. Also it does not work so well in extreme cold and deteriorates where it is necessary that it should stand idle for long periods, or when left lying on cement floors, a treatment which would not be recommended for any kind of belt.

There are certain definite, important qualities in leather belting which are necessary for the successful transmission of power. These are as necessary in other types of belting but are more easily pointed out in connection with leather belts, as they vary more widely in different grades of belt or under various methods of treatment. These qualities are:

1. Strength
2. Stretch
3. Pliability and texture
4. Adhesion or coefficient of friction
5. Elasticity
6. Durability
7. Serviceability

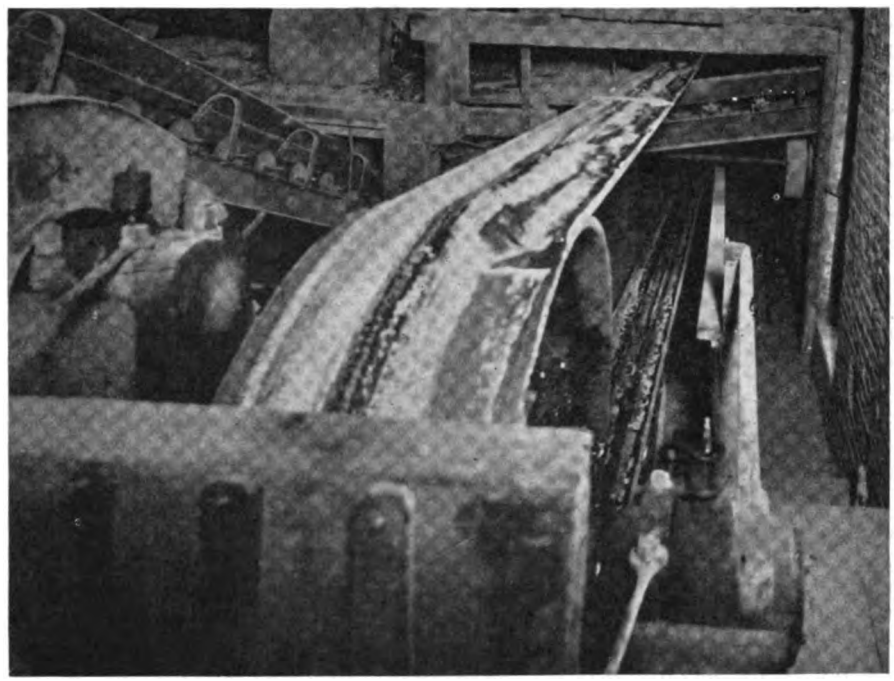
The ideal leather belt would be one in which all of these qualities are at



This belt has been operating satisfactorily for over 30 years.

This 6-in. belt drives 30-in. pulleys on 18-ft. centers at 164 r.p.m. The crossed belt at the left has been in operation for 15 years. The service record of these two belts is largely due to the treatment and care which they receive at the plant of the Agawam Co., Agawam, Mass.

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A solid-woven cotton belt operating under severe conditions in a brick yard.

Thick coatings of dust as are shown here on the inside and outside of this 14-in. double belt are severe treatment for any belt. In ordering belts for dusty locations such as this an allowance is usually made for decreased adhesion due to the dust.

the highest point which it is possible to make them. However, due to the characteristics of leather, if some of these are made high others must necessarily be lower. The best belt is that which has each of these qualities developed as high as is possible without sacrificing any of the others. Belting is not made for strength alone, or for pliability alone, or for minimum stretch alone, but for the greatest strength, consistent with the minimum stretch, consistent with the maximum pliability, consistent with long life, and so on with the other qualities requisite for a good belt. The strongest part of the hide comes from the belly cut of leather, but if this were used in the manufacture of belt, both stretch and durability would be sacrificed to get strength, which is not the most essential quality for ordinary belt drives. The belly cut, although the strongest, not only stretches more than others—a factor which affects its serviceability as well as its durability, and adhesion and elasticity—but also stretches unevenly and requires more taking up of the belt. For this reason the manufacturers of the better grades of belts do not use this cut of leather for making belts. On the other hand, if too much stretch is taken out of the leather during its manufacture it will not be as strong as is desirable. All of these factors are influenced by the tanning of the leather, quality of the hide selected, and the manufacturing processes, particularly the "currying" operation where natural oils are worked back into the leather to give it flexibility and life. Even this may be overdone. However, there is use for all belts made out of the sections of the hide which is ordinarily cut up for this purpose. The belt user should be familiar with his service conditions and choose the best belt for that service. More on this phase of the subject will be given in a later article.

It is difficult to tell by observing a belt how these different qualities or characteristics are blended together in that belt. Recently the Bureau of Standards of the United States Department of Commerce, in cooperation with the Leather Belting Exchange, an association of leather belt manufacturers, prepared standard specifications for leather belting which have been adopted by the Government on belting purchases. A copy of these specifications may be obtained by addressing Louis W. Arny, secretary, The Leather Belting Exchange, 417 Forest Bldg., Philadelphia, Pa. While some of the tests mentioned are very difficult to make and require special apparatus as well as considerable skill, many of them are so simple that they may be made in a small shop. It is not to be expected that the lower grades of belting would come up to all of these specifications but they can be used to judge whether a belt is of the grade which it is claimed to be.

It is well to add a word of caution against choosing belts purely by appearance alone, as it is possible, by the treatment or working of the leather or of the materials which are worked into it, to give any appearance desired. Moreover, a high gloss has no value, except in appearance, as the gloss or polish must be worn off before the belt grips well on the pulley. This gripping of the pulley is due to the suction of the tiny vacuum cups in the surface formed by the openings in the leather where the hairs have been removed in the tanning process. For this reason the hair or smooth side of the belt should always be run next to the pulley. Tests have shown that when the flesh side of the belt is used next to the pulley the belt transmits only about 60 per cent of the power that it will when the smooth side is next to the pulley.

One important advantage of leather belts is that they can easily be made endless in any shop and if the sections of leather are well graded and matched in making up the belt, it can be used satisfactorily in the operation of such machines as wood planers, and other wood working machines which operate at high speed and are affected by an uneven joint or section of a belt.

While the best leather belts for general and most special services are made of oak tanned hides, chrome tanned leather belts are particularly useful under conditions giving a combination of high and extremely moist temperature. They are recommended wherever the temperature exceeds 150 deg. F. Also as they are extremely pliable as well as thinner than oak tanned leather they are coming into wider use for high-speed work on small pulleys. Although oak belts require six to ten months to tan in contrast to a few weeks to tan chrome leather, the latter will not displace oak tanned leather for most purposes, it does not at present have as much uniformity in quality and costs more.

There are, in addition, a few miscellaneous types of belts which do not have extensive use. One of the most common of these is what is known as camel's hair belt. This is a solid-woven belt made of camel's hair instead of cotton fabric. It has a comparatively high coefficient of friction and little slip until it reaches its rated capacity. Camel's hair belts

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are more expensive than other fabric made belts, but they stand up well under severe operating conditions and are used quite commonly on drop-hammer service, where they are exposed to both heat and moisture. If they are to be made endless, it must be done at the factory as the short fiber makes splicing difficult.

Some steel belts are used, although they are not at all common. These are made of an endless flat, thin strip of steel.

In choosing any belt it should be carefully borne in mind that unless external operating conditions are such that any belt is ruined in a short time, the consideration of first cost is an insignificant item. The two main considerations in the operation of a belt are: (1) Ability to deliver the power expected of it and, (2), continuity of service without excessive attention and adjustments. A belt which slips continuously is not only wasting power but also will have a short life and be continually giving trouble. Choosing the right belt will eliminate most of the slip. It does not require a great deal of attention or lost power to more than absorb any saving in first cost of a poor belt over a good one.

The conditions under which belts operate, types of drives and practical methods of determining the proper size of belt, will be taken up in the second section of this article. Other sections will cover inspection and maintenance records and methods as well as reclamation work.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assisting in furnishing information and photographs for this and the other articles which will follow in this series: Louis W. Arny, Sec., The Leather Belting Exchange, 119 S. Fourth St., Philadephia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; The Bristol Co., Waterbury, Conn.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co., Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Indianapolis, Ind.; Imperial Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; New York Rubber Co., New York, N. Y.; Charles A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Rubber & Asbestos Mfg. Co., New York, N. Y.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

Connecting Induction Motors

(*Continued from page 146.*)

In the table for the delta connections a *C* is shown for the top connection in group 2. For the top connection in group 4 is a *B* and for the top connection in group 6 is *A*. These are the only places in which the series delta connection differs from the series star connection. Then to change the connection from series star to series delta, we connect the top of group 6 to an *A* lead, the top of group 2 to a *C* lead, and the top of group 4 to a *B* lead. This can be done by cutting open the star leads at the star point and splicing on enough wire to make the connections to the proper leads.

These diagrams and connection tables can be used with either a long or short type of jumper regardless of how the leads, stars, etc., are brought out and independently of the direction in which the winding proceeds. For example, suppose we have a six-pole series star-connected motor with top-to-top jumpers which we want to change to two-parallel star. First we consult the table for six-pole three-phase star with top-to-top connections. Finding the *Two-Parallel* line in this table, we start at any lead and pass through three groups. The end of the third group will be a star point, and the beginning of the fourth group will be a line lead. Therefore, it is necessary only to take any lead to start with and checking through three groups cut the jumper between the third and the fourth groups. Bend the end of the jumper attached to the third group in towards the center of the stator, then with a piece of string or tie wire, tie the other part of the jumper to the original lead upon which we started. This ties the original lead to the beginning of the fourth group. After this is done for one phase, repeat the same process for the other two phases. Then connect together the three leads which have been bent in towards the middle and these will form the second star connection. It is not necessary to connect both of these star points together. To complete the operation the line leads are then attached to the other halves of the jumpers to which they were tied by the tie wires or strings.

This method can be applied to any connection. It would be time well spent to follow each connection in the tables and see where and how the break is made from one connection to another.

A delta connection is the one that is likely to trip the beginner, therefore a few more words upon it may be valuable. Suppose that we have a two-parallel delta six-pole top-to-top connection and we want to reconnect it to series delta. In the two-parallel connection each line lead will have four taps connected to it, two top jumpers and two bottom jumpers. For the purpose of this discussion we may consider that all the top leads are incoming leads. The bottom leads could be chosen if desired, but in this case we shall take the top leads. If the top leads are chosen they must be kept as incoming jumpers throughout the job. Considering the top leads as the incoming leads take any one line and cut off the bottom leads attached to it. Do likewise to the remaining two line leads. After this is done there will be six bottom leads projecting from six groups. Then take the first bottom lead to the right and calling this group No. 1 count over to group No. 4. Join these two groups together. This will leave four leads. Take the next group to the right and calling this No. 1 count over to group No. 4 and connect the bottom leads of these two groups together. The remaining two leads are then connected together. To check the connections start at any one line lead and follow the winding through each phase. Then if the connection is correct the three phases will have been passed through and the end of the operation will bring us to the line lead upon which the start was made.

The following general rules for reconnecting three-phase motors should be remembered. Pole-phase groups 1 and 4 apart belong to the same phase but are of opposite polarity. If we enter group No. 1 on a top lead we must enter group No. 4 on a bottom lead. Likewise pole-phase groups 1 and 7 apart belong to the same phase and have the same polarity. In this case if we enter group No. 1 on a top lead we must enter group No. 7 on a top lead.

In the next issue of INDUSTRIAL ENGINEER this article will be continued. If any reader finds it hard to follow the points discussed, I shall welcome a letter referring to his particular difficulty which will be cleared up in the articles that follow.

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THIS IS THE THIRD of a series of articles by Mr. Martindale started in the October, 1922, issue. The first article dealt with troubles arising from the wrong grade of brush and the second, which appeared in the December issue, took up troubles due to faulty brush operation. Two more articles are to follow: One will deal with troubles caused by armature and field defects and the other with troubles from sources external to the machine.

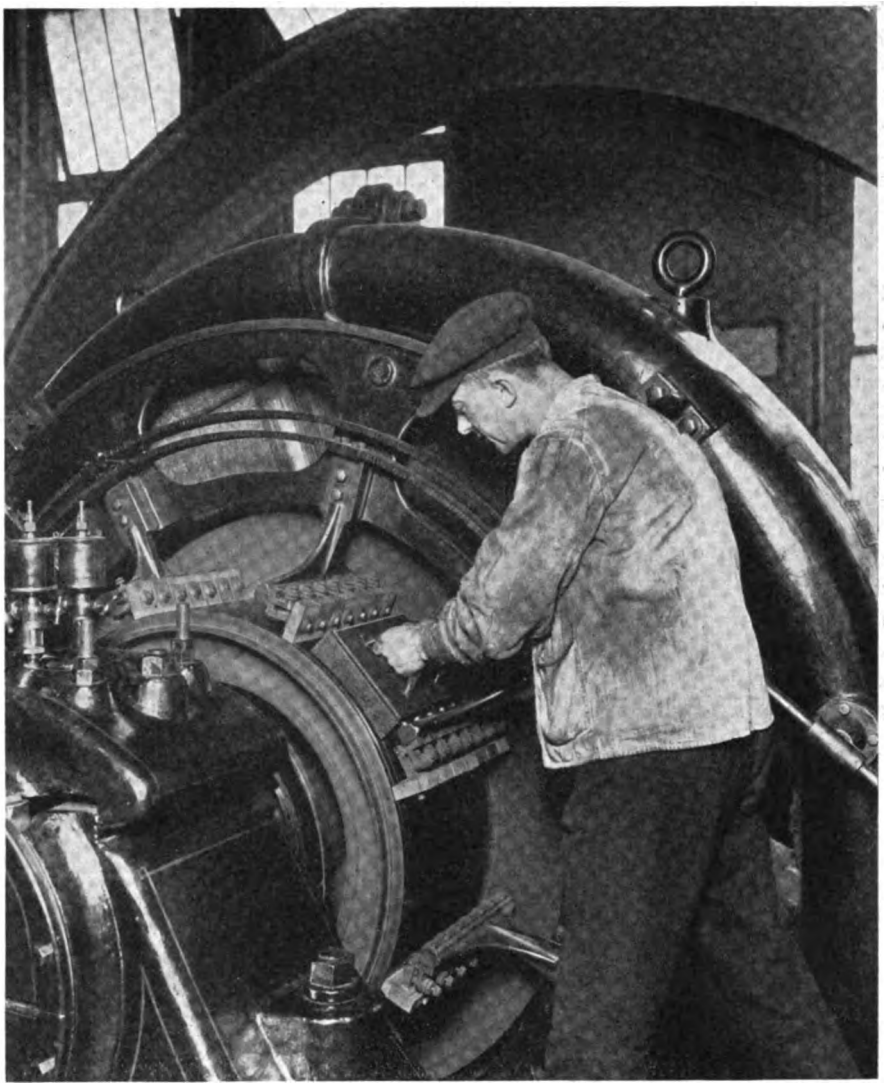
Some of the Ways

Defects In a Commutator

Show Up as Troubles At the Brushes or Poor Condition of the Commutator

By E. H. MARTINDALE

President, The Martindale Electric Company, Cleveland, Ohio



The operator in this illustration is removing ridges and flat spots on the commutator by the use of a commutator stone moved back and forth across the face of the copper while the machine is in operation.

THIS article follows the outline of Section III of the double-page chart showing brush and commutator troubles that appeared with the first article of this series by the writer on pages 476 and 477 of the October, 1922, issue of INDUSTRIAL ENGINEER.

1. *Brush Studs Not Parallel to Commutator Bars.* — This trouble might have been treated in the previous article as due to faulty brush operation since the trouble is sometimes due to crooked brush studs, but in other cases, especially on small commutators, it is due to a twisted commutator. In either case the effects are quite similar to those treated under "Brushes too thick" in the article by the writer that appeared in the December, 1922, issue of INDUSTRIAL ENGINEER. These effects are caused by the brushes spanning too many bars. The path of the short-circuit current, however, instead of being under the face of each brush is from one brush up through the brush stud and down through another brush on the same stud. This, therefore, adds the danger of loosening brush shunts as the short-circuit current passes through them.

2. *High Mica.*—High mica may be caused by sparking that burns away the copper leaving the mica higher than the bars and by several other defects as checked on the chart that appeared in the October, 1922, issue already referred to. The direct effects of high mica are to prevent the brushes from making proper contact with the surface of the commutator.

It is now very general practice to undercut mica even when commutators are operated in dirty locations. During the past few years the "V" shaped slot has grown rapidly in favor for two reasons. First, it will not collect dirt, and second, this shape of slot automatically prevents leaving thin strips of mica along the edges of the bars which is a frequent result when slotting saws, hack-saw blades or other devices are used to cut a "U" shaped slot between the bars.

When a machine operates in a very dirty location an added precaution is sometimes taken of coating the slots with an air-drying, oil-proof, insulating varnish. The varnish should be one that will dry glass hard and that may be stoned or sanded from the face of the commutator without peeling loose from the edges of the slots. The varnish should further be able to withstand sparking and heating without decomposition or softening.

The best way to prevent all of the troubles shown under high mica is to either keep the mica undercut *properly* or keep it stoned down even

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with the bars. It requires more pressure to grind copper than mica and the claim has been made by some operators that the particles of abrasive rolling under a commutator stone will cut deeper into the mica and keep it very slightly below the surface of the bars of the commutator.

3. *High Bar.*—A high commutator bar will usually cause a flat spot directly back of it whether or not the mica is undercut. This is because the high bar lifts the brush from the commutator and the latter travels several bars before the brush gets back to a good contact. If you have a flat spot on a commutator, examine carefully the bar just ahead of it. If the bar is high it will usually be brighter than the average because of the high brush pressure on that bar when it lifts the brush thereby applying the total brush pressure to a single bar.

The best remedy for a high bar is to tighten the commutator bolts while the commutator is hot and then grind the commutator while it is running at full speed.

If all of the bars are not equally gripped by the V-ring, some of them may be slightly loose. A turning tool has a tendency to push those bars in and then when the commutator is brought up to full speed, the centrifugal force throws the loose bars out, making them higher than the others.

Grinding at operating speed prevents this shifting of the bars.

4. *Low Bar.*—The most frequent cause of a low bar is the dropping of a heavy tool or other article onto the commutator and thus driving one of the bars in. It is sometimes caused by the spring in a turning tool particularly when some of the commutator bars are softer than others, permitting the tool to dig deeper into the soft bars. The spring of the turning tool may not be more than two or three ten-thousandths

Fig. 1—These are single end and double end commutator slotting files that are used when making a V shaped slot in the commutator.

Fig. 2—When using this motor-driven slotter, the slotting tool is clamped onto the armature shaft and driven by a flexible shaft connection.

Fig. 3 — Portable hand-operated commutator slotter driven by a motor through a flexible shaft.

Fig. 4—Motor driven commutator slotter for use in the repair shop.

Fig. 5 — The upper illustration shows a portable slotter driven by compressed air. The lower illustration is another portable design driven by a motor through a flexible shaft.

Fig. 6—This hand-operated, motor-driven slotter makes use of a small saw the width of the slot that is to be cut between bars.

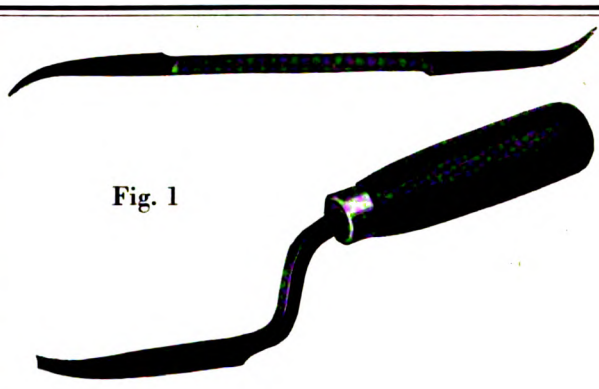


Fig. 1

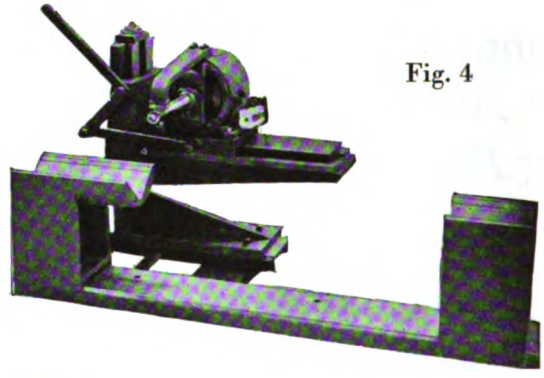


Fig. 4

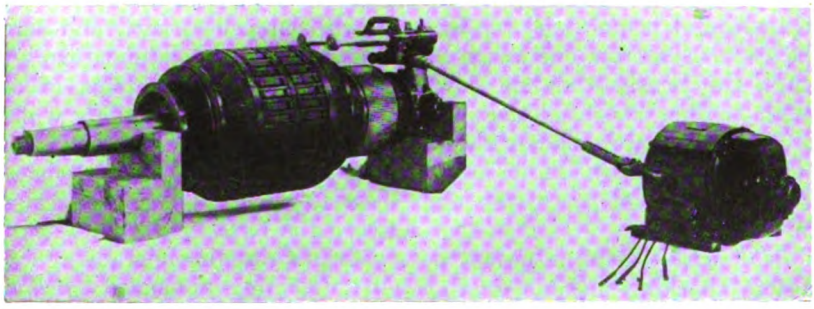


Fig. 2

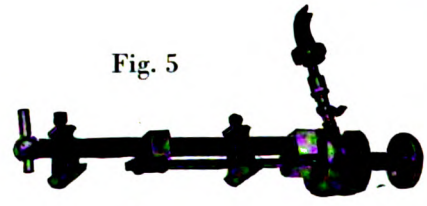
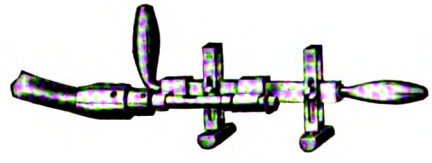


Fig. 5



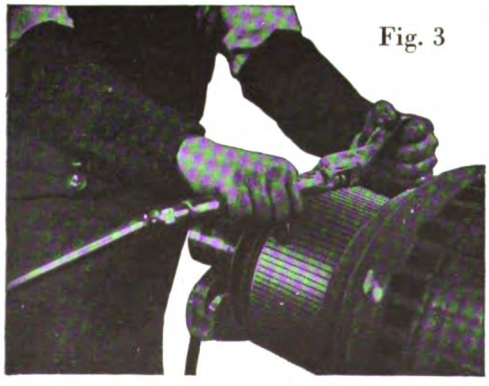


Fig. 3

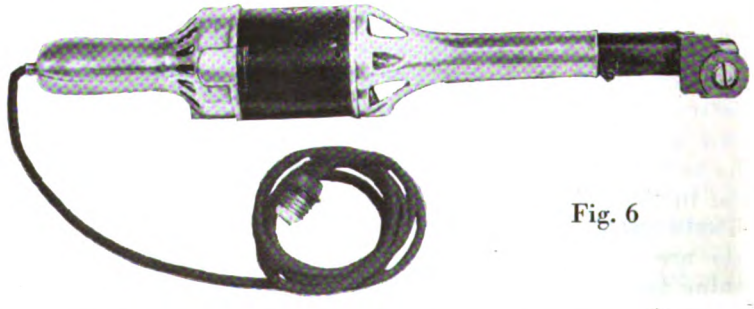


Fig. 6

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of an inch, but this is sufficient to prevent proper contact between the brushes and the low bars.

A low bar will practically always start a flat spot. When a flat spot once starts it will grow very rapidly because of the severe sparking every time it passes under a brush.

A flat spot at one point on a commutator very often starts other flat spots equally spaced around the commutator corresponding to one-half the number of poles. Thus, a six-pole machine will show three flat spots 120 degrees apart and an eight-pole machine four flat spots 90 degrees apart. This is caused by the temporary interruption of current at the original flat spot throwing an extra load on the other studs of the same polarity. Most large industrial works have a well-organized fire department because a minute saved may mean a building saved. Give a flat spot the same prompt attention. Every time the spot passes under a brush the fire is burning deeper into it. When the spot is one bar wide it may be stoned out entirely in a few minutes with the loss of a very few thousandths of an inch from your commutator. Don't use sandpaper because it is too flexible even when used on a wooden block and will only clean up the spot without entirely removing it. Delay may necessitate the removal of an eighth of an inch of perfectly good commutator to remove one neglected flat spot.

5. *Eccentric Commutator at High Speed.*—As long as the speed of the commutator is low enough to permit the brush to follow the movement of the commutator, eccentricity is not serious, but as soon as the speed becomes high enough to tend to throw the brush from the commutator it will cause a low brush pressure just behind the high spot of the commutator and will start a flat spot at that point.

Where much eccentricity is present hand commutator stones are not recommended. The commutator should either be turned with a tool or ground with a stone held in a rigid support.

6. *Rough Commutator.*—A rough commutator may be caused by flashovers or by the use of coarse sandpaper. While a rough commutator may cause some sparking due to poor contact between the brushes and the commutator, its main effects are commutator heating due to increased friction and rapid brush wear that is caused by the rough surface. (*Continued on page 171.*)

Four Armature Slotting Tools for the Repair Shop

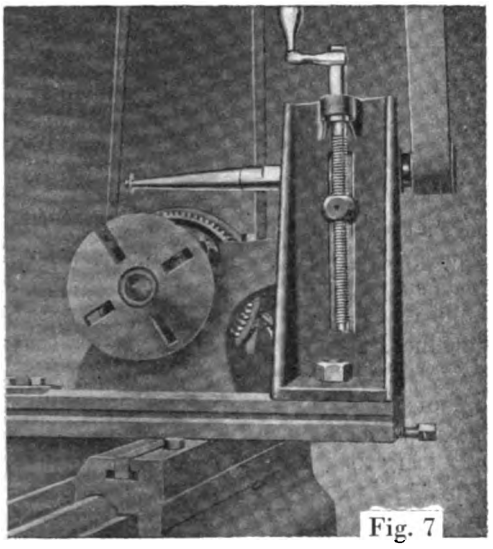


Fig. 7

Fig. 7—This design of commutator slotter is made for mounting on a lathe.

Fig. 8—This is a portable type of repair shop commutator slotter that can be used with armatures of various sizes.

Fig. 9—This is a portable type of motor driven slotter for use on large commutators.

Fig. 10—This illustration shows how an ordinary shaper can be used to slot a commutator when fitted with the proper shape of tool.

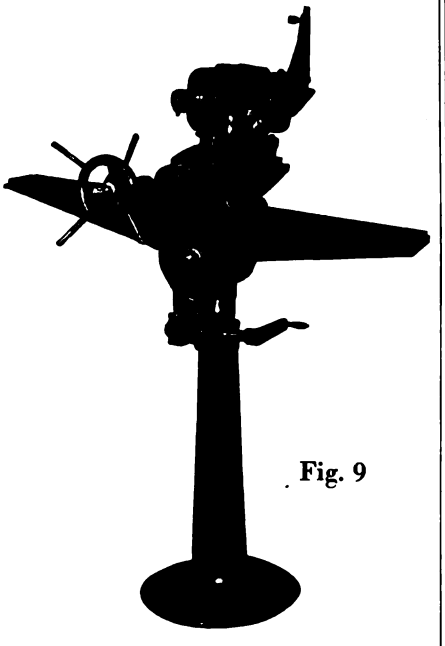


Fig. 9

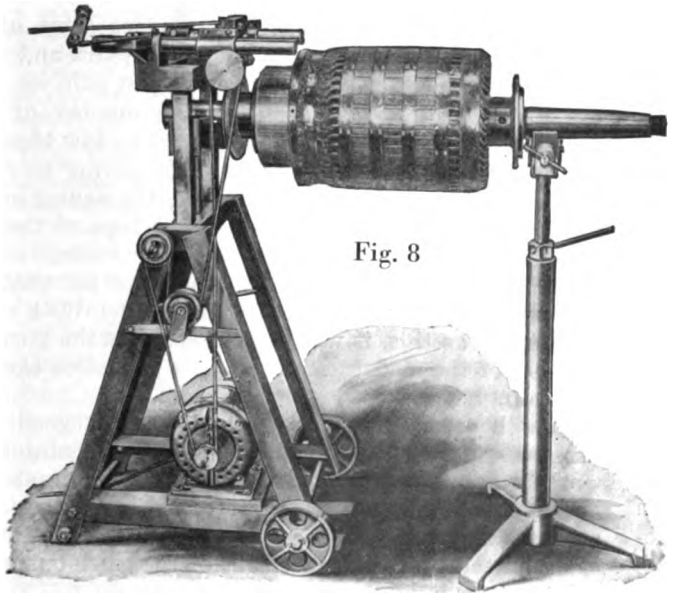


Fig. 8

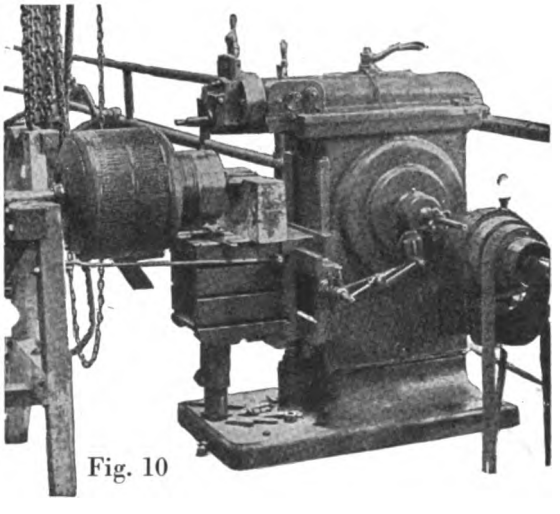


Fig. 10

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, March, 1923

Is Your Job Running You?

EVERY executive on whom directors and stockholders place the responsibility for success or failure of the operations of business pays most of his attention to plans of the future and day-to-day results as they show up in production data and financial statements. He must depend upon an organization for initiative and ability to assume a responsibility for working out the details of his plans and seeing that these details are properly executed. But as you go down the line in an organization there is evidence in spots and places of men who have initiative and a willingness to assume responsibility but fail to get results largely because they are not running their job —their job is running them. And in these cases one of two reasons can be found for the condition. The management lays its plans well and details the work but fails to designate responsibility for these details and indicate the day-to-day checks that will be used to measure the results. In such cases errors of judgment and lax methods come to the top of the table only after long periods and valuable time is spent in correcting conditions that should be spent in following through on the original plans.

The second reason is found in a tendency to throw around a man and his work such overlapping divisions of responsibility that his time is spent in conferences with his associates and he is continually reporting on details to others who are directly interested only in the execution of their own plans. Under such conditions the time of such a man is taken from the details of his own responsibility and the job runs him in every sense and the results he secures show it.

Between the head of a business and the foreman in charge of production too many department heads and too many opportunities to interpret and give instructions spells confusion and waste and kills initiative and the willingness to assume responsibility over which there is no definite and individual control. The successes of small business have shown this and the wastes in large organizations have proven it.

Every job should be analyzed from the bottom upward, not from the top downward. Take the repair shop of an industrial works for example. The extent of repairs and general upkeep depends upon the extent of the equipment operated and the productive life that this equipment is known to possess. If output is held up by frequent failures, the causes cannot be located in discussions among executives. The production methods and the machines must be examined and watched by those who are in direct charge. Then the recommendations that result must be acted upon and the remedies applied. An executive discussion on the production sheet of a machine bay that does not show, say, seven failures of a crane motor in a week and the superintendent is not provided with a detailed report of these failures and there is no way to show these in terms of lost-time delays on the production sheet, is just a talk-fest on generalities.

If your job is running you and you are constantly checking up on things you did not expect to happen and you know how they can be prevented, it's time to stop and climb up on top of that job even if it takes a little overtime thinking and a heart-to-heart talk with the boss. If he doesn't get the point, it's time for you to look around for one who will.

When Maintenance Costs Are the Key to Replacements

INSPECTION and maintenance are usually neglected rather than overdone. But some old equipment requires so much time in inspection and so many repairs that the expense of keeping it in operation is not warranted. In such a case it is self evident that the money spent in putting in new equipment to replace the old will often earn a dividend that will interest any business man who studies investments from the standpoint of the dividend yielded.

The wisdom of replacing equipment that has served its useful life, was emphasized by a steel-mill engineer recently. In talking to a section meeting of the American Institute of Engineers this engineer said:

"A number of our old mill-type motors repeatedly got into trouble. Grounded coils and commutators as well as short circuits kept us worried. A few modern mill-type motors were bought to replace some of the old ones. The result was to cut the repairs and shutdowns 90 per cent. Of course the biggest gain we made by this change was in reducing the number of shut downs. These are worth a great deal in lost time and production. In addition, however, the saving in repair expenses was considerable. In fact, the saving on repairs per year equalled a large percentage of the first cost of the motors. Where the maintenance on the obsolete motors cost $1.50 per horsepower per year, the new motors cost only 15 cents or one-tenth! With such a percentage as this, it was easy to see that the purchase of more of the modern motors was a profitable expense. Accordingly we have purchased them."

The thought summed up is this: It is good business to spend enough money in organized maintenance work to know how much it costs to keep equipment in good operating condition. It is poor business to keep on spending money in this way when a part of it can be reclaimed by the replacement of the worn-out equipment with new.

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Concerning the Kind Word

SINCE the first issue of INDUSTRIAL ENGINEER appeared under that name and its present editorial scope, now 14 months ago, we have received more than 1,000 letters from readers commenting on articles that have appeared and furnishing suggestions for other articles and requests for specific information for which they find a need. These letters have taken advantage of our repeated assurance that such suggestions from readers will be carried out in every instance where the request is possible and practicable and that the paper is edited for men responsible for works operating and maintenance problems by the men who are studying these problems and have worked out particular phases of them. Although it is not always possible to answer in detail all of the letters received, we take this opportunity to say that none has been overlooked and that in due time the paper itself will answer through the material published the points which have been brought up.

These letters have revealed to us three definite things about our readers. First and most important, they are thinkers and doers—men who take their jobs seriously and find time to read and digest information that will broaden their experience and help them to do the same job better the next time it comes up.

Second, they read the advertisements in INDUSTRIAL ENGINEER as well as the text pages, for the letters we have received contain such remarks as:

1. INDUSTRIAL ENGINEER is simply fine. I enjoy reading everything in it, and get something of value from every department—even the ads. 2. In all the various departments I find something worth while. I get things that I can use in my work or add to my stock of knowledge on most every page, even the advertising section. I'd hate to miss a copy. 3. INDUSTRIAL ENGINEER is the best magazine for the practical man that is published. I find it very interesting and useful from cover to cover. 4. The data I have secured I have never seen published before and I have been in maintenance work for 21 years. If through fire or otherwise I should lose my past issues I would consider the loss irreparable. No insurance could replace them or make up the loss. 5. The first issue I have received contained an article that I have referred to more times than any other book that I own. It is within hand reach all of the time. 6. Enclosed is my renewal for two years more. I think my subscription runs out in March and I don't want to miss a copy. INDUSTRIAL ENGINEER is the most practical magazine I have been able to get and I have tried them all. 7. I can fairly see INDUSTRIAL ENGINEER grow from month to month. Your articles which get at the root of certain troubles in connection with maintenance work are always helpful. Ideas as to how other plants carry on are always in order. 8. The editorial policy as outlined in the past year is one of which you may be very proud as it is liberal enough to satisfy the technical as well as the practical man. During the past 10 years it has been my lot to operate plants which had to be kept from the scrap pile with the very smallest possible expenditure for new apparatus—hence any articles which describe equipment and its uses are doubly welcome to me, etc., etc.

Failure to read the statements made by the manufacturers concerning their equipment made for industrial use in a paper such as INDUSTRIAL ENGINEER is certain to mean that a lot of useful information is being overlooked. When it is realized that manufacturers devote a great deal of time to the preparation of their statements and use every known scheme of the advertising art to call attention to the fact that they stand ready to furnish at no cost practically any information that may be asked for concerning their equipment, a careful reading of their statements will often point the way to securing particular information that you have been looking for. Bulletins on equipment are a particularly good source of information for men who frequently have to take down and overhaul industrial equipment. In fact, an up-to-date file of worthy bulletins, worthy because they contain useful information besides generalities, is a valuable treasure in books if you know when and how to use them. This is the reason INDUSTRIAL ENGINEER carries in each issue a department devoted to "Trade Literature You Should Know About."

The third thing embodied in the letters received is a cordial and free expression of appreciation for assistance furnished through articles that have appeared. Naturally this is keenly appreciated by the editors, but whatever of credit is due in this connection must be returned to the contributors and the readers who are working with the editors and furnishing helpful suggestions, results of experiences and other practical assistance that will carry out to the fullest degree the statement of one reader when he said: "I expect you think it has taken a long time to tell you what I think of your paper or rather *our paper*, since you say it is built on the thinking of its subscribers." In this connection we recall the story of a certain American who was visiting London and gave a waiter the following breakfast order: "Two boiled eggs please, some toast, coffee and a kind word." The waiter brought the order and started to leave in silence. Whereupon the American asked, "How about the kind word?" The waiter then bent over and whispered, "Don't eat the eggs!" We, too, as editors want our readers to take us literally and furnish the kind word in suggestions, constructive comments and requests for information that you need whenever and as often as the spirit moves you.

Big Enough to Be Small

LAST month there were two red numbers on the calendar—February 12 and 22. What did they mean to you besides a holiday? To help you answer this question in case it comes up again, these two incidents printed in a recent number of the house organ published by the Hygrade Lamp Company of Salem, Mass., furnish a sharp-pointed suggestion:

"What are you crying about?" asked a man of a twelve-year old girl standing by a gate on a street of Springfield, Illinois.

"The drayman hasn't come for my trunk and I shall miss the train."

"Dry your tears, sis, I reckon we can fix that." Up went the trunk on this strong man's back and off they went to the station in time for the train.

That man was Abraham Lincoln. Big enough to be small.

* * * *

"Heave away there! Yo heave!" A corporal was giving orders to a squad trying to move a timber. But the timber was too heavy.

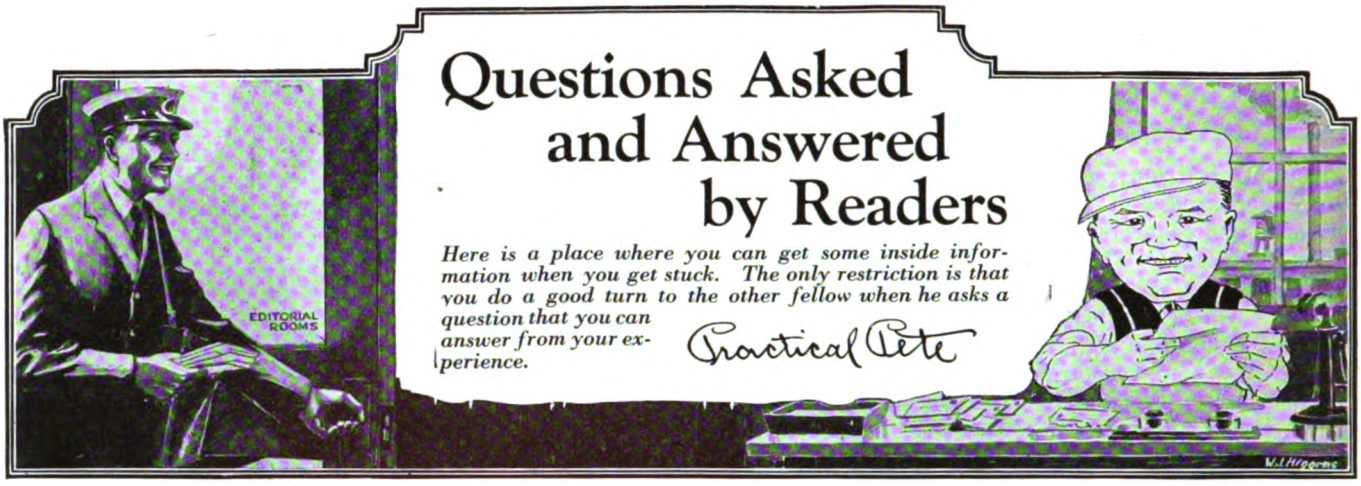
Presently a man rode up on a horse and inquired: "Why don't you help them?" "Not I; I'm a Corporal."

The man dismounted and lined up with the soldiers. "Now, all together—Yo heave!" When the timber went into place, the man turned to the corporal and said: "Next time you have a timber too large for your men to move, just send for your Commander-in-chief."

That man was George Washington. Big enough to be small.

By observing the results accomplished by men who are big enough to be small, many of the secrets of success in all work can be discovered. In this connection we quote Abraham Lincoln again, "If you intend to go to work, there is no place better than where you are. If you do not intend to go to work, you can't get along anywhere."

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Who Can Answer These?

Elimination of Arc Lamp Noises—Will some reader please tell me how I can overcome the noise in a. c. arc lamps.
Bridgeport, Conn. G. R. C.

* * * *

How to Figure Ampere Rating of a Cable—How can I find the rating of a cable when I know the number of wires in the cable and the size of these wires? For instance, what is the rating of a cable that is made up of seven No. 14 wires?
Sartell, Minn. L. S.

* * * *

Flexible Cord and Reel for Coal Loader—I would like to get some two-wire flexible conductor for an outdoor coal loader. Also some kind of a reel that will keep up the slack as the loader is moved from one place to another. Would some of your subscribers please state what they find to be the most serviceable material and reel for this work?
Norwich, Conn. G. E. G.

* * * *

Trouble With Sparking at Brushes—Will you please answer the following and explain what the trouble is? We have a 500-kw. rotary converter which has for some time been giving trouble from sparking. The commutator has been turned down and slotted and still it is sparking. The spark is a light blue, leaving the brush on the leading side. It does not burn the commutator and acts like a static spark. It is not quite so bad when running with the compound switch in.

We have been over the field connections and everything else we could think of that would cause it to act this way. What do you think the trouble comes from?
Natick, Mass. J. A. P.

* * * *

Rewinding Motor for Four Speeds—We have a 5-hp., 1800 r.p.m., 220-volt, 3-phase, 60-cycle induction motor which has 48 slots in stator and is wound with 24 coils made of 13 turns of No. 15 wire. This motor is now connected single star. There is room in the stator for another winding due to there now being only one coil in each slot. There are 55 bars in the rotor. Short circuiting rings are ½ in. square, laminations 3¾ in. wide.

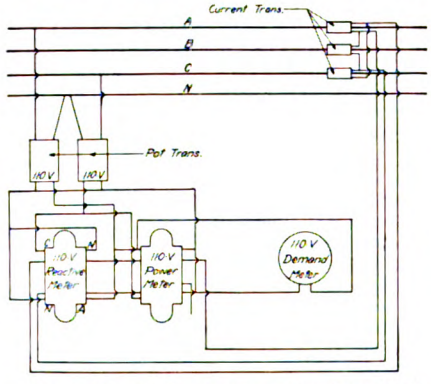
We would like to know if it is possible to rewind this motor with two sets of winding and secure four speeds: 600, 900, 1200 and 1800. The horsepower required at slow speed is about one.
Logan, W. Va. B. S.

* * * *

Location of Starting Equipment for Synchronous Motor—We are about to install a 350-hp. synchronous motor on a circulating pump. Would it be practicable to install the starting equipment about 100 ft. from the motor at the main switchboard, although the man starting the motor would not be able to see it? However, a man standing about 25 ft. from the motor could easily signal the operator. The main switchboard is on a gallery above the motor and if possible we would like to have the switchboard operator handle the starting and stopping of the pump.
Hudson, N. Y. F. R.

* * * *

Voltage at Meter Terminals—The accompanying illustration shows the wiring for meters in our plant. I would like to have some reader check these connections and indicate what



the voltage is across the terminals of the reactive meter at the following points: C to N, N to A and C to A.
Racine, Wis. T. G. L.

* * * *

Charging Storage Battery—I would like to charge the storage batteries in our plant from a 220-volt d. c. exciter circuit of our 2,300-volt a. c. generators. If some readers will show a diagram of connections and a practical method for reducing the voltage, I will appreciate it very much.
Amenia, N. Dak. J. P. C.

Answers Received To Questions Asked

In the January issue Mr. Meisner and Mr. Heinback give the same coil grouping and connections in reply to E. L. of St. Anne de Beaupre. Both are correct for the winding specified.

If I were having this motor rewound I would make up 36 coils, each with half the number of turns in the 18-coil winding and connect them in groups of three coils per pole per phase. This would give a more uniform distribution and make practically no difference in the operating characteristics. CHAS. SUGG.
Atlantic Coast Line Railroad,
Wilmington, N. C.

* * * *

Size of Pulley on a Motor—The writer would like to request readers of Industrial Engineer to indicate what is considered good practice in the dimensions of pulleys for d. c. and a. c. motors. For instance, is it good practice to use a pulley larger than the diameter of the armature? If not, why?
Orange, N. J. R. H. S.

This will answer the question by R. H. S. concerning dimensions of motor pulleys. Pulley dimensions have been standardized by motor manufacturers and depend upon the motor speed and horsepower. Decreasing the pulley diameter increases the strains on the motor shaft and bearings and for this reason each motor has a specified minimum pulley diameter. Maximum diameters are used in applications where speeds higher than the motor speed are required such as in connection with woodworking machinery and grinders. In practice the pulley diameters are limited by the belt speed which should not exceed 5,000 feet per minute.

Standardized pulley dimensions can be obtained from any motor man-

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ufacturer and are given in the handbook of the Electric Power Club.

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

Reconnecting Motors for Half Speed—We have two 7½-hp., 60-cycle, 220-volt motors operating at 1800 r.p.m. These motors are connected in two-parallel delta. They have 40 slots with 4 coils in a group. Is it possible to reconnect the winding for a speed of 900 r.p.m. and get as good performance from the motors as when they were connected for 1800 r.p.m.?

Medina, O. C. F. N.

Since the power of a given motor is approximately proportional to the speed, C. F. N. in the January issue cannot expect to reduce the speed of his motors and maintain operating characteristics. At 900 r.p.m. he will get probably less than half the power that he gets at 1800.

CHAS. R. SUGG.
Atlantic Coast Line Railroad.
Wilmington, N. C.

* * * *

In answer to C. F. N. of Medina, Ohio, I want to say that I feel sure he is wrong in stating that there are 40 slots with 4 coils per group in his 7½-hp. motors. If, however, he is right, he may disregard the data given here, and I would say there is something peculiar about these machines.

As C. F. N. states that these motors are running at 1800 r.p.m. and connected 2-parallel delta, we know that these are 3-phase, 4-pole machines. Now with 4-poles per phase we have twelve poles per machine of four coils per pole, making 48 coils. It is impossible to balance 40 coils in twelve poles correctly, even if an irregular grouping of 3 and 4 is used. So we will assume that C. F. N. made a mistake and meant 48 slots instead of 40 slots.

To change these machines to operate at 900 r.p.m. it becomes necessary to change the number of poles per phase from 4 to 8. This will now make 3-phase, 8-poles per phase, or 24-poles per machine. We will now have only two coils per pole. It will be seen here also that if the machine has 40 slots this cannot be done.

The result of the change in connections from 1800 r.p.m. to 900 r.p.m. is as follows: Whereas the machine was 3-phase, 4-poles per phase, 4-coils per pole connected 2-parallel delta, it is now 3-phase, 8-poles per phase, 2-coils per pole, connected 2-parallel delta. The machine will have the same operating characteristics and same electrical efficiency but, of course, it will be reduced one-half in power. The horsepower of the machine after the change is proportional to its changed speed as per the following equation: X : 900 = 7½ : 1800 or 3.75 hp.

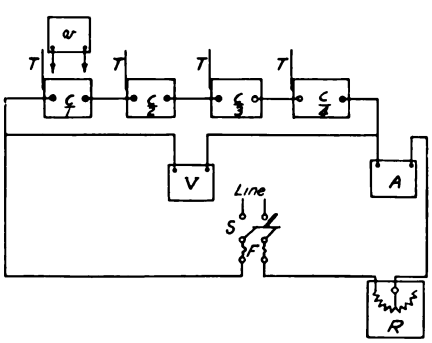
Darby, Pa. GEORGE WM. HANLON.

* * * *

Testing Motor Field Coils—Is it good practice to apply voltage across the shunt fields of a motor for several hours to test for heating? I am having trouble with the blowing of the main fuse on my generator, although the machine is not overloaded. Can you tell what causes this trouble?

New Orleans, La. A. C. H.

Although several answers have been published to the question by A. C. H. regarding the practice of applying voltage across the shunt field coils of a motor, I would like to state my experience, gained from actual tests on many motors and under various conditions of apparent faulty construction or other faults.



Connections for field coil excitation heat test.

In the diagram, *A* is an ammeter; *V* a voltmeter; *v* a voltmeter for testing drop-per-coil; *R* a resistance; $C/_1$, $C/_2$, $C/_3$ and $C/_4$ are coils; *T* indicates thermometers; *F* fuses and *S* a line (d.c.) switch.

I have found that the application of a d.c. voltage not exceeding the normal exciting voltage is not objectionable, and will cause no harm to the coils providing the current sent through them is under control and not above the normal operation value when the motor is in service. The shunt fields are designed for the motor voltage requirements and a certain current value will result under full load on the motor. This field current value is determinable by the use of an ammeter.

With the coils connected according to the accompanying diagram, with the current value being small at the start and increased gradually by means of the resistance until the full load excitation current is established, the thermometers will show the conditions of the various coils and their temperatures should not be allowed to rise over 40 deg. C. for a 40-deg. C. motor or over 50 deg. C. for a 50-deg. C. motor. Normally this rise in temperature can be adjusted by lowering the exciting current after a period of time so that the temperature rise shall be the controlling factor of the test.

It is good practice to test the voltage drop across each coil at the start of the test and any unequal "drop" accounted for before the coils are subjected to further heat tests. If the coils are in good condition the application of a d.c. voltage, across them and with the normal exciting current passing through them, will not cause the temperature rise to become rapid, but will show a gradual rise and a continued equal rise after the maximum is reached.

Any sudden temperature rise should be investigated before damage to the coils results.

If it is desired to maintain a flow of air over the coils during this test a fan should be employed and so located that the amount of air from it, over the coils, is as nearly equal as possible to the amount of air which normally flows over the coils when the armature is in motion and the resulting air from the motor fan is used to keep the coils cool.

NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

* * * *

Removing Coils From Motors Without Damaging—Is it possible to strip an armature or stator of coils and save these coils for rewinding?

Brooklyn, N. Y. I. T.

In reply to the question by I. T., there are on the market a number of good varnish removers that will work satisfactorily for this purpose, although they must be used with reason. If a liquid will soften the varnish enough to allow the coils to be withdrawn without tearing, it will spoil the insulating quality of the varnish which was absorbed by the covering on the wire. It will probably also ruin the insulating enamel on enameled wire.

The writer has found the following method satisfactory for stripping d. c. armatures up to 10 hp. in size, where we want to save the coils: The armature is soaked overnight in gasoline, standing it on end with the commutator above the surface, in an old barrel provided with a tight cover. This method has the advantage of loosening the varnish and making it easy to remove the old tape, etc., from the coils. After

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taking out of the gasoline the coils are left in the air until all the gasoline has evaporated.

On small and large a. c. stators the best method is to run current through the winding until it becomes warm enough to soften the varnish. If the coils are to be saved, the current should be turned off before the winding starts to smoke. On large d. c. machines a gas torch can be used to heat the core. If the torch is applied before the wedges are removed, the coils will not be burned. When only a few coils are to be lifted or removed, the top and bottom leads of the defective coils are lifted out of the commutator and all the top leads attached to one line and the bottom leads to the other line. Then current is allowed to flow through the coils until they are warm enough to be removed.

When the armature or stator of a small fan or fractional horsepower motor requires complete winding and a new commutator, the machine is put in a boiling solution of sal soda. It is allowed to boil for at least three hours. This loosens all the varnish and makes the motor easy to strip, although it destroys the commutator and any fiber end rings. The core must be baked dry before it is rewound in order to drive out the moisture between the laminations.

Detroit, Mich. A. C. ROE.

* * * *

This will answer I. T.'s request for information on stripping an armature or stator and saving the coils for rewinding.

It is impossible to do this with motors that have closed slots and that have been dipped, especially if dipped in Bakelite. But if they have open slots and have been dipped in varnish insulation, and they use formed coils, they can be lifted out of the slots and can be saved for rewinding. The first few may be spoiled but the rest can be saved. This can be done with a long tapered piece of fiber which will fit the slot in the armature or stator. By driving it from one end between the coils they can be lifted up without bending or injuring the coils, providing the insulation is not dried too much. CARL STEINIGER.

Chicago, Ill.

* * * *

In regard to the inquiry by I. T. in INDUSTRIAL ENGINEER concerning the removing of coils from motors without damaging them, I would say that in certain cases this can be done and it pays to do so. If time is important, however, the quickest way is to strip the motor and put in new coils throughout. If some extra time is allowable, the coils can be unsoldered, wedges removed and the coils lifted without damage. This applies to motors that have not been overheated enough to char the insulation.

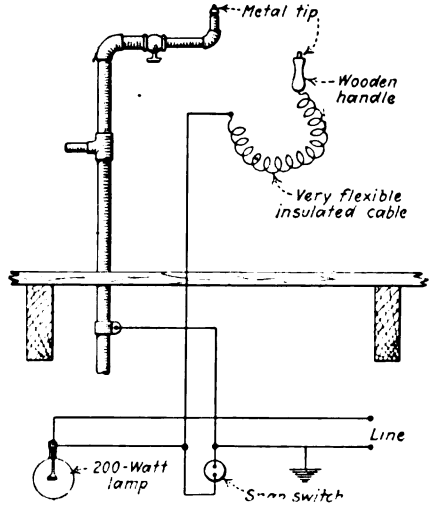
After the coils have been removed, inspect them carefully for damage, particularly at the ends. The good coils can be cleaned up, dipped in insulating varnish, baked and with the addition of new paper cells will function as when new. I have used this method on motors from 5 hp., 110 volts, to 500 hp., 2,300 volts, with good results. PHILIP N. EMIGH.

Chief Engineer,
Mountain Water Supply Co.,
Indian Creek, Pa.

* * * *

Lighting Gas by Electricity—I would appreciate details of a method by which a 60-cycle, 110-volt, alternating current circuit can be used to light a gas jet instead of using matches. A sketch of a device for this purpose would be helpful.
Wilmington, Del. J. H. G.

The use of 110-volt, 60-cycle alternating current is not to be recommended for lighting gas unless stepped down to a low potential, as there is always great danger of accidentally receiving a serious shock. The accompanying sketch, however, shows a frequently used scheme which gives complete satisfaction and is perfectly safe if precaution is taken not to touch the tip of the handle or the bare wire due to worn insulation, while standing on a wet floor or touching any grounded object with the other hand. If a gas jet is used, it should have a metal tip. In operation, it is simply necessary to turn on the gas and tap or scratch the end of the handle on the gas burner or jet. The resulting spark readily ignites the gas.



Use the cellar lamp in connection with a gas lighter.
The snap switch is necessary only when the lamp is to be lighted when the gas lighter is not in use.

The lamp used may be employed for this purpose alone, or may be ordinarily intended for illumination.

If a small transformer is available, it should be wound for any voltage between 3 and 10 volts and may be connected with or without resistance, depending on the voltage and size of the transformer. About 50 volt-amp. is the right capacity. This scheme, however, consumes a small amount of power continuously unless the primary is disconnected each time, which, of course, lessens its convenience.

There are standard gas jet lighters on the market which operate from a battery or a low-voltage transformer. In one type, the gas is turned on manually and is lighted by pulling a small chain while in another type the pushing of a button at some distant point automatically turns on the gas and lights it, while the pushing of another button turns off the gas, thus giving the advantages of a remotely controlled light when using gas. VICTOR H. TODD.

Summit, N. J.

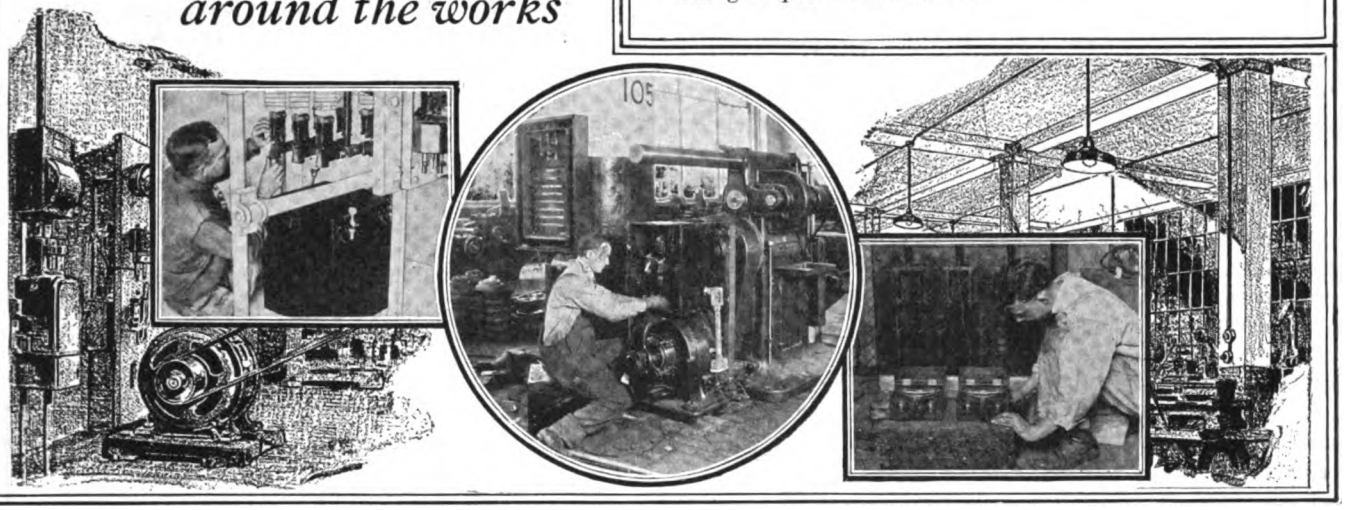
Omission in Item on Page 108 of February Issue

AN UNFORTUNATE omission occurred in the item on page 108 of the February issue of INDUSTRIAL ENGINEER which answered the question on RLM Standard Dome Reflectors. This omission was in the second sentence which should read: "Several years ago, the Illuminating Engineer of one of the lamp manufacturers, feeling dissatisfied with the types of industrial reflectors being sold for use with Mazda C lamps, called a conference of all the leading manufacturers of steel reflectors, and of the illuminating engineers of the Mazda lamp manufacturers." The omission occurred by the dropping out of the words "leading manufacturers of steel reflectors and of," which made one full line of the original copy, and was simply skipped when typing the original matter. This is an important reference to the origin of the conference which led to the origination of the RLM Standard Dome Reflector.—EDITORS.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Care in Oiling Bearings of Motors Will Prevent Trouble

OILING motors appears to be a simple enough procedure, but unless the oiler observes certain precautions trouble is likely to result. For example, flooding the bearings so that the oil overflows or runs out frequently results, if the motor is a direct-current machine, in the oil getting on the commutator, brushes and brush holders. In addition to the commutator trouble which the oil can cause, it soon takes up carbon dust and other dirt and forms a sticky paste which may prevent the brushes from working properly in the holders. Oil overflowing from the pulley end of the motor will be drawn into the armature and thrown off onto the field coils and frame, where it forms a sticky coating which is not only hard to remove, but is, in time, injurious to the insulation. Those who take pride in clean machines take pains to prevent excess oil overflowing to absorb dust.

Before adding oil to the bearings, the oiler should find out whether the oil rings are working properly, if the bearings are provided with these, and also determine the level of the oil. Otherwise there is danger of putting in too much oil.

Bearings should be drained at intervals depending on the service conditions, particularly with reference to the amount of dust and dirt in the air, and filled to the proper level with fresh or carefully filtered, used oil. After some weeks or months of use the oil in the bearings of a motor or machine becomes dirty and unless the grit and foreign matter is removed occasionally it will cause undue and unnecessary wear of the bearings.

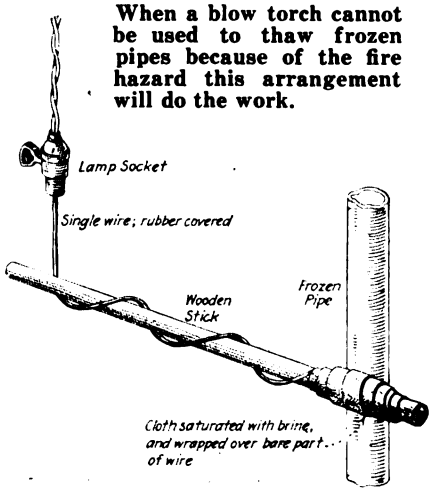
JOS. B. HUMPHREY.
Chief Electrician,
Blatz Brewing Co.,
Milwaukee, Wis.

Simple Method of Thawing Frozen Water Pipes By Electricity

THERE are cases where frozen water-pipes cannot be cleared safely by use of a blow-torch, and where hot water used to melt them will injure ceilings, or do other damage. Where lighting current is to be had, a simple and effective thawing outfit can be made as follows:

Remove from the end of a piece of electric wire all insulation for a distance of 6 in. and wrap this bare part around the end of a stick which is long enough to reach the place to be thawed. Wind at least ten layers of cloth around the bare wire so that it completely covers the copper and tie the cloth in place with string. Run the wire to the nearest lamp-socket, and connect by means of an attachment plug with the wire fastened under one of its screws, the other screw left clear. Dip the cloth end of the stick in strong salt water, and apply to the pipe. If there is no action, reverse the plug, or attach the wire under the other screw. When connections are right the cloth touching the pipe will begin to steam. It should be kept wet by frequently dipping.

DEXTER W. ALLIS.
Whitman, Mass.



When a blow torch cannot be used to thaw frozen pipes because of the fire hazard this arrangement will do the work.

Some of the Causes of Ring-Fire and How It Can Be Prevented

RING-FIRE is a term usually applied to an ailment most frequently met in slow or moderate speed direct-current machines. It can be recognized by characteristic thin streaks of fire that appear to extend from one brush position to the next and might deceive one who is unfamiliar with the symptom into thinking that the trouble had its origin in the brushes themselves. The point of maximum voltage between commutator segments is the position midway between any two brush holders, and the arcing reaches its maximum at that point. Ring-fire usually results from a partial breakdown of the mica insulation between adjacent commutator segments and the burning is quite localized as a rule. The points at which it takes place are often only a fraction of an inch in length, but the continuous arcing

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eventually burns holes sufficiently deep to cause a breakdown in the insulation of one or more commutator segments and the temporary shutdown of a machine.

Undercutting of mica is a fruitful source of ring-fire. Although freedom may be secured from trouble due to high mica, the grooves resulting from undercutting readily collect foreign matter, such as copper and carbon dust, which are highly conductive, and these, with perhaps a little oil thrown from a leaky bearing, are sufficient to start local burning between segments. Unfortunately, it is not always possible to use brushes which are sufficiently abrasive to keep down the level of the mica insulation to that of the commutator bars, and therefore it is often necessary to undercut the mica. This usually consists in cutting grooves to a depth of from 1/32 to 1/16 inch. Often the point of a file is used as the tool, making a V-shaped groove whose edges remain above the commutator bars and, through impairing the brush contact, probably assist the development of the ring-fire by charring any foreign matter that gets into the grooves.

Perhaps the best method of obviating ring-fire is to cut down the mica for some distance and, so as to leave no grooves in which dust can accumulate, refill with some material which is a good insulator and will wear down with the commutator bars. Plaster of paris is suitable for this purpose. The first operation is to turn the commutator free of flats and irregularities. Next, a semi-circular groove about ¼ in. deep is turned in the commutator close to the armature conductors. Care must be taken to see that all short-circuits between bars, especially in the edges of the grooves, are cleared after turning. The mica between the bars is then cut to a depth of from 3/16 to ¼ in. If no other means are available, a piece of hack saw fastened in a suitable holder may be employed. In all cases the mica must be cut square to the bottom of the grooves.

The plaster of paris for filling up the grooves should be perfectly clean and free from lumps. The plaster under normal conditions sets rapidly but one part of dextrine mixed with seven of plaster of paris will retard hardening. The filling should be worked into the grooves between the commutator bars until they are filled solid. At least a day is necessary for setting, when the commutator should be smoothed to remove all roughness occasioned while cutting down the mica. After this treatment the commutator will have a perfectly smooth surface which will be retained under running conditions. Ring-fire seldom develops in high-speed machines and in such cases as do occur any filling similar to that described is undesirable, as centrifugal force tends to dislodge the filling. However, for machines of slow and medium speeds the method of treatment referred to is very effective.

R. TOKEA.

Walton-on-the-Thames, Surrey, England

Determination of Power Required in the Operation of Sawmill Machinery

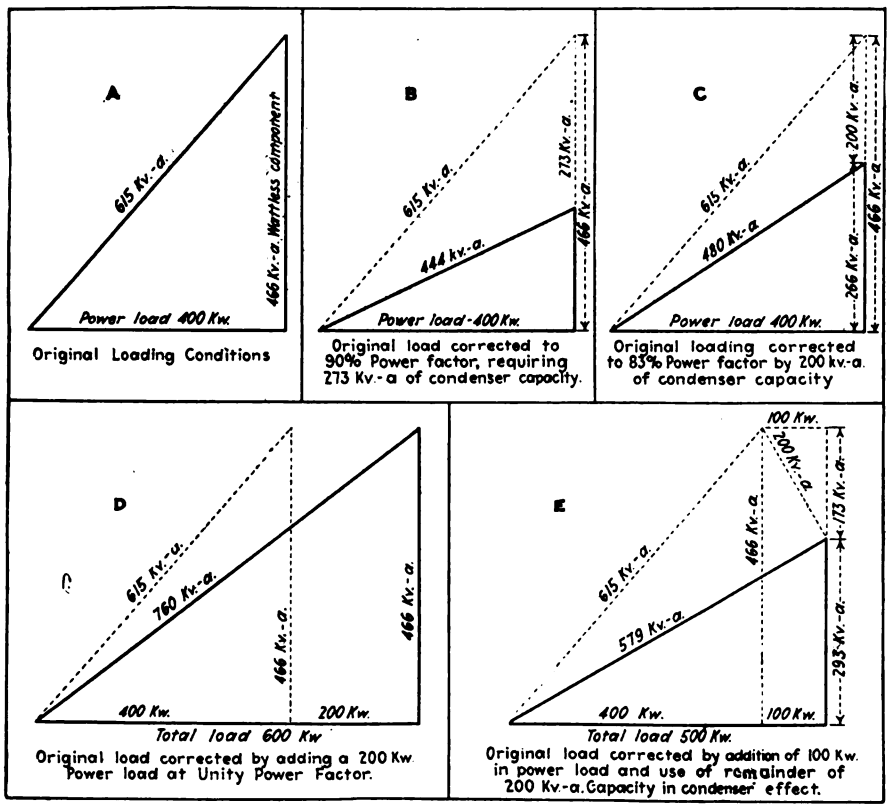
IN THE accompanying table are the results of some tests to determine the amount of power required by some of the machines in a large sawmill. All of the machines, with the exception of the band saw, are driven by 440-volt, 3 phase, squirrel cage induction motors; the band saw is driven by a variable speed slip ring induction motor.

The test was conducted by taking volt- and ammeter readings of the input to each motor. Inasmuch as the loads on the motors are subjec-

Amount of Power Required to Drive Sawmill Machinery for Various Operations

Machine	Speed R.P.M.	Piece Handled	Operation	Feed Feet per Min.	Horse-power Required	Remarks
Gang saw, 36 in. x 12 in.	258	Cedar cant, 24 in. x 12 in.	Cutting into 1-inch boards	7½	93	Crank not balanced
Gang saw, 36 in. x 12 in.	258	Cedar cant, 6 in. x 34 in.	Cutting into 1-inch boards	15	115	
Gang saw, 24 in. x 8 in.	260	Cedar cant, 15 in. x 4 in.	Cutting into 1-inch boards	6	20	Has balanced crank
Single cut, 8-inch band saw	Rim speed 10,000 ft. per min.	Fir cant, 12-in.	Cutting into 1-inch boards	112	100	Has variable-speed motor
Single cut, 8-inch band saw	Rim speed 10,000 ft. per min.	Cedar cant, 10-in.	Cutting into 1-inch boards	160	110	
Shingle machine			Cutting shingles		60	Without balance wheel
Shingle machine			Run idle		10	
Shingle machine			Cutting shingles		45	With 175-lb. balance wheel
Set work on saw carriage		Cedar log, 5-ft. diameter, 18 ft. long	Move log	20	12	
Berlin planer No. 350	3,000 (Side-and-top heads)	Cedar, 1 in. x 6 in.	Plane all around	220	55	
Centrifugal pump	1,800				20	Pump suction, 5 in.; discharge, 3 in.; suction lift, 16 ft.; head, 125 ft.

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The possibilities in the use of a generator as a condenser to correct the power factor are explained in this item and illustrated graphically when applied under different conditions.

to wide fluctuations, the results given in the table must be considered as close approximations. Also, in calculating the horsepower required by the different machines, the efficiency of the motors was disregarded, but account was taken of the 70 per cent power factor which obtains in our mill. F. G. BONN.

Port Hammond, B. C.
Canada.

Calculating Generator Capacity for Use as Condenser to Correct Power Factor

IT IS often found desirable to use a generator as a condenser for power-factor correction. The writer has noted, however, that in some cases a generator has been either considered for such service or put into use without first really knowing what the result might be. The following points cover the conditions most commonly encountered and should be carefully considered before attempting to make such power-factor improvements in any system: (1) A thorough check of the system should be made, covering especially the average maximum load and the power factor of the feeder systems. (2) The generator must correspond in the characteristics of phase, voltage and frequency with the system with which it is to be used. (3) Will the generator be used as a motor, either wholly or in part, for additional load? (4) Will it be used as a motor, either wholly or in part, for existing load, or will it be used as a condenser only?

A concrete example will help to make clear the method of solving these problems. Assuming an existing average maximum load of 400 kw. with a power-factor of 65 per cent, it is desired to increase the power-factor to 90 per cent. It is also assumed, for the purpose of this example, that a generator of 200 kva. capacity is available and that the windings of the generator are such that it will carry 200 kva. at zero leading power-factor.

Case 1. Generator to be used as a condenser only. The assumed 400 kw. load at 65 per cent power-factor makes a kilovolt-ampere load of $400 \div 0.65 = 615$ kva. The wattless lagging component of this load amounts to $\sqrt{(615^2 - 400^2)} = 466$ kva. (See Fig. A.) With the same power load of 400 kw. carried at 90 per cent power-factor, the kilovolt-ampere load would be $400 \div 0.90 = 444$ kva. (See Fig. B.) With a load of 444 kva. and a corresponding power load of 400 kw., the wattless component is $\sqrt{(444^2 - 400^2)} = 193$ kva. The difference between 466 and 193 wattless kva., 273 kva., must be made up in leading wattless kva. supplied by the condenser effect if the power-factor is increased from 65 to 90 per cent. But this is 73 kva. more than the assumed capacity of the generator available. Consequently it cannot be used to accomplish the desired result.

With a wattless component of load amounting, as in this case, to 466 kva. corrected by the assumed 200 kva. of condenser generator capacity, the resulting wattless component would be 466—200=266 kva. (See Fig. C.) With a load of 400 kw. and a wattless component of 266 kva., the resulting power-factor would be 83 per cent, $400 \div \sqrt{(400^2 + 266^2)} = 0.83$.

Case 2. Generator to be used as a motor to carry its full capacity (200 kva.) in additional load. Under this condition, with the added load carried at unity power-factor, the wattless component remains at 466 kva. and the actual power becomes 400+200=600 kw. The total kilovolt-ampere load amounts to $\sqrt{(600^2 + 466^2)} = 760$ kva. The new power-factor will be 80 per cent ($600 \div 760 = 0.80$).

Case 3. Generator to be used to carry an additional power load of 100 kw. with the remaining 100 kva. capacity used for condenser effect. With the machine carrying a power load of 100 kw., the total condenser capacity available from a 200 kw. machine will amount to $\sqrt{(200^2 - 100^2)} = 173$ kva. (See Fig. E.) Subtracting this amount from the wattless component of the original system leaves a resultant wattless component of 293 kva. (466—173=293). With the added 100 kw. of power, the total power load on the system is 500 kw. (400+100=500), and with a wattless component of 293 kva., the total kilovolt-ampere load amounts to $\sqrt{(500^2 + 293^2)} = 579$ kva. With a power load of 500 kw. and a corresponding 579 kva. load, the power-factor becomes 86 per cent ($500 \div 579 = 0.86$).

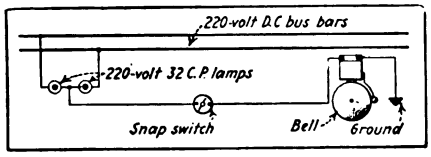
Case 4. Generator to be used at its full rating as a motor to carry existing load. The simplest method in this case is to take out of service for a time the motor or motors to be replaced by the change and then check the existing power-factor. A new set of load readings should be taken at this time, and with the new load and power-factor values the computations may be carried on as in Case 2. R. W. LLOYD.

Ainsworth, B. C.

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Lamps and a Bell Connected to Give an Alarm When Circuit Is Grounded

A SIMPLE scheme for detecting grounds has operated successfully in the foundry in which I am located. The electrical system in this foundry furnishes energy for traveling cranes equipped with 220-volt motors. In the sub-station are two motor-generator sets with switchboard and other equipment, and adjacent to this is the electrical repair shop. Most of our time is spent in the repair shop, and the plant is not large enough to employ an operator for the switchboard. Therefore a ground of an intermittent character on a crane motor may be present for some time before it is noticed.



A ground on the system causes a lamp to light and the bell to ring.

Two lamps are used as ground detectors and are connected as shown in the sketch. A bell and a snap switch are inserted in the ground line. When the system becomes grounded the bell as well as one lamp gives the alarm. The snap switch is then turned off until the ground is removed, to stop burning of the contacts. For about three years this has decreased repair work by helping to remove the trouble before damage is done.

P. WHALEN.
Fort William, Ont., Can.

Motor-Generator Set Connected to Render Various Services

THE accompanying diagram shows the method of connecting which made it possible to use an ordinary motor-generator set for any of the following purposes: (1) Generator for 250-volt direct current; (2) generator for 440-volt, 3-phase, 60-cycle alternating current; (3) electric welding service; (4) synchronous condenser to improve power factor.

The unit is a 350-kw. Allis-Chalmers motor-generator set of the 3-bearing, direct-connected type and consists of a compound wound direct-current generator and a synchronous motor which has its field excited from the main 250-volt direct-current buses. The normal speed of the set is 600 r.p.m. It is one of three similar machines installed for the purpose of converting alternating current at 440 volts, 3-phase and 60 cycles to direct current at 250 volts, for the operating of traveling cranes, lifting magnets, adjustable-speed machine tools, and other purposes where the characteristics of the direct-current motor made its use desirable. Central station power is used for the alternating current drives in the plant as well as for driving the motor-generator sets which in turn furnish the direct-current power for the cranes and other equipment mentioned above. Formerly when this service was interrupted the consequences were serious. The stopping of gas producers and blowers caused damage and delay at heating furnaces, and lack of power for pumps caused a heavy drain on the city water supply. Perhaps the most serious feature, however, was the possibility of about 80 tons of open-hearth steel "freezing" in the ladles. To guard against this possibility a steam-driven generator was installed to furnish direct current at 250 volts. Now when an interruption occurs this unit is started immediately and direct current is thrown on the buses to provide power for the ladle cranes. If alternating current power does not come on within three or four minutes the main 22,000-volt alternating-current service switch is opened and the motor-generator set started from the direct-current end by the graduating resistance. The series field of the direct-current generator is short-circuited by a switch and the brushes rocked forward to provide the proper commutation for running as a motor. These brush positions are marked to facilitate changing over. The running speed which, of course, determines the frequency of the generated alternating current, is regulated by the generator field rheostat, while the generated alternating current voltage is regulated by the synchronous motor field rheostat. Connection is made to the 440-volt alternating current buses by the starter and line switch provided for controlling the set from the alternating current end. Pilot lamps (not shown) warn the operator when central station voltage returns to normal.

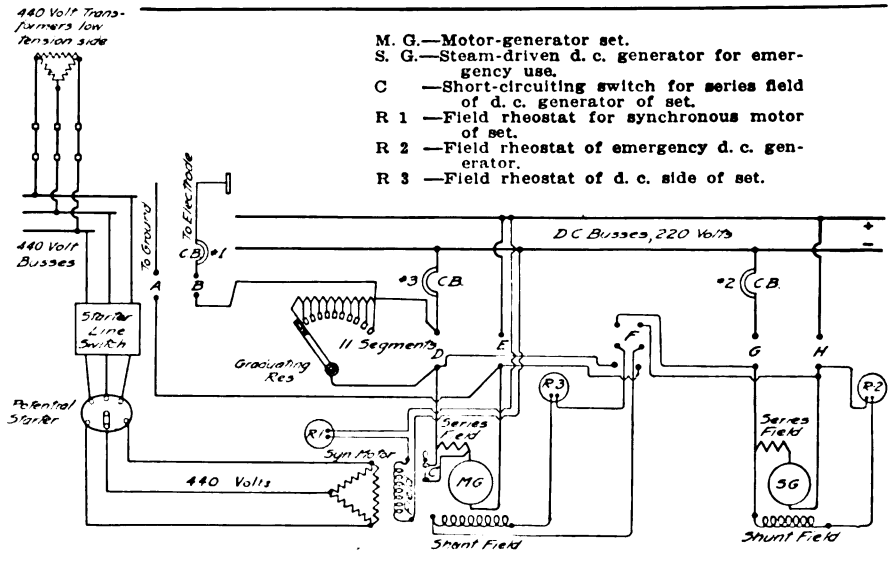
The set is used for electric welding by short-circuiting the series-field winding of the direct-current generator and reducing the voltage to the desired value by manipulation of the field rheostat. The graduating resistance is used as a steadying resistance and for controlling the welding current.

During the times when the set is not being used to supply alternating or direct current line power it is used as a synchronous condenser to improve the power factor, the increase being on the average about 15 per cent. As the welding current may be taken off at normal speed and reduced voltage it follows that the set may be used to perform these duties simultaneously.

A. W. MCAULY.
Chief Electrician, Edgewater Steel Co., Oakmont, Pa.

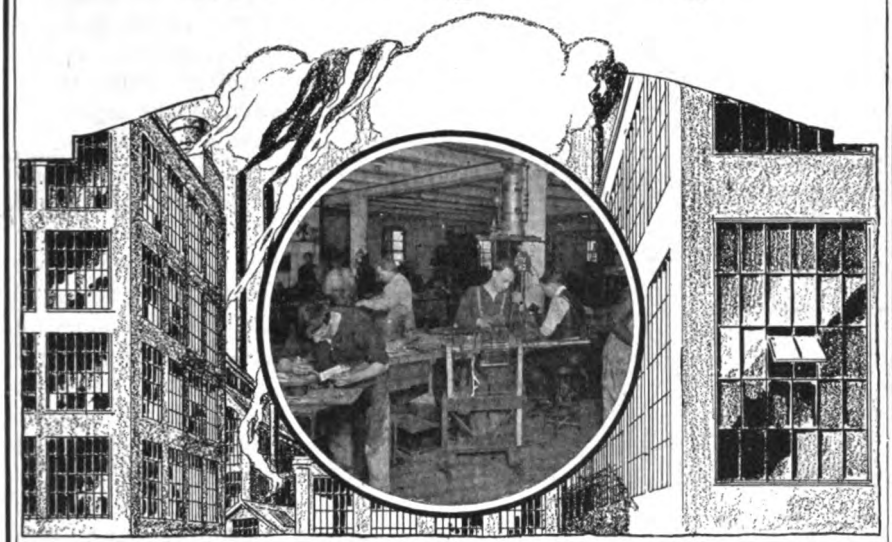
Diagram of connections for motor generator set used for various purposes.

This set is normally driven from the a. c. end but is used to convert d. c. energy supplied in emergencies by a local steam-driven unit to a. c. energy in case of a failure of the central station a. c. service. This set may also be used to supply energy for welding service at the same time that it operates as a condenser to improve the power factor.



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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Simple Tool May Be Used for Many Purposes in Repair Shop

A TOOL which was developed in our repair shop and has been found to be very useful for a number of different purposes is shown in the accompanying illustration. As will be seen it is made of hexagon tool steel bar, with the ends flattened and formed as indicated. For our purposes it has been found advisable to make this tool in three different sizes, 14 in., 16 in. and 20 in. in length, with the other dimensions altered correspondingly.

The thin, curved end of the tool, designated as *Y* in the illustration, is used for lifting armature coils, forming the ends of coils on the core, stretching coils when they are being placed in the slots, and so on. The other end, *X*, is shaped much like the end of a pinch bar and is used for opening boxes, pinching off gears, pinions, pulleys and similar work.

When making this tool care should be taken to make all of the edges round and smooth, so as to avoid possibility of injury to the insulation on coils. Also, the curvature of the coil-lifting end of the tool should be such that the point is high enough to clear the top edge of the coil slot when the tool is on the bottom of the slot. As shown at *D*, the point *Y* should be considerably thicker than the curved portion behind it.

Chief Electrician, Walworth Mfg. Co. Kewanee, Ill. E. J. FORD.

This tool can be used for lifting armature coils and as a pinch bar. With the simple directions given here any or all three sizes of bar can be made easily.

Simple Suggestions to Be Followed When Dipping and Baking Armatures

EXPERIENCE gained in the treatment of a large number of motor armatures has indicated certain methods which should be followed to produce the best results. Careful draining after dipping and thorough baking are very important points. The general process may be divided into two classes, depending on whether the armature requires overhauling or a complete rewinding. Where it is desired to overhaul it, the recommended steps are as follows:

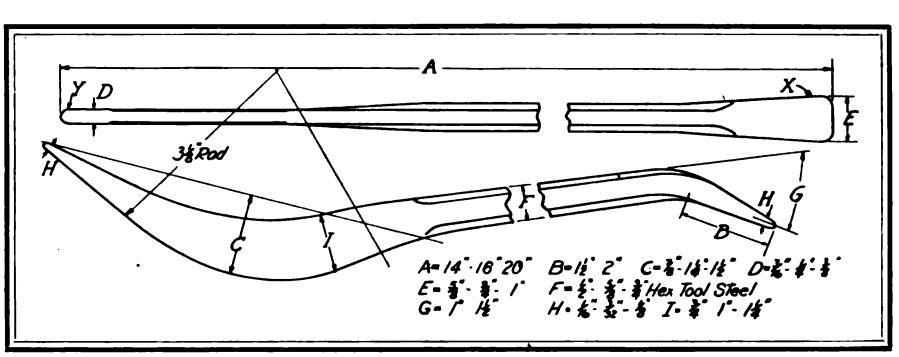
When the armature is very dirty remove the accumulation of dirt and grease with a scraper. Then clean with benzine or gasoline by brushing or dipping. Remove the bands and insulation on the end windings and make any necessary repairs. Make sure that the core bands are tight and that the coils are tight in the slots. If either is loose, reband, placing a filler in the same slot, when required, to get pressure on the coil, at the same time making sure to have the bands down on the iron.

Where wedges are used inspect for tightness, and when it is thought that they will not tighten when dipped rewedge, using fillers under wedges to make the coils tight. Place temporary bands on armatures if there is a tendency for the coils to spring out of position when dipped. Place the bands so that the armatures will drain readily after dipping. Some operators may wish to dip and bake armatures without removing bands or hoops. In such cases care must be taken to see that the armatures drain and bake out.

Heat the armature in an oven with freely circulating air, using an oven temperature of 200 deg. to 220 deg. Fahr., for the length of time given: Armatures below 18-in. in diameter, twelve hours; armatures 18-in. to 30-in. diameter, eighteen hours; armatures over 30-in. diameter, twenty-four hours.

It has been suggested by one operator that armatures can be preheated in a storage furnace utilizing the waste heat from the main oven and that thus a saving may be effected, provided that the arrangement can be worked out satisfactorily.

While the armature is still hot, dip it in a good grade of baking insulating varnish. A clear amber baking insulating varnish with a specific gravity of 0.835 is recommended, but other varnishes may be used, the specific gravity depending upon the varnish and the thickness of the varnish coat desired.



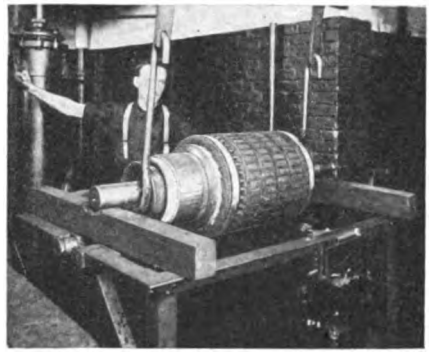
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Should the varnish be too heavy thin with benzine. Dip the armature in a vertical position, commutator end up, varnish coming only to the commutator neck, allowing the armature to remain in the varnish for five minutes. If vapor rises from the varnish in large quantities, it indicates that the armature was too warm when dipped. Place all double-commutator armatures in a horizontal position so they can be rotated in varnish to twice the slot depth. In case they cannot be rotated as described, pour varnish over the armature until the windings are filled. After an armature has been dipped, wash off the varnish on all finished metal parts with benzine. The commutator should not be immersed, as varnish may get inside of the commutator and be trapped, neither draining out nor baking. Such a condition is undesirable. Some operators roll armatures in a tank, instead of completely dipping them, and apparently get good results. When this is done the armatures should be rotated slowly several times to insure that all coils are thoroughly soaked with the varnish.

Drain at room temperature until dripping ceases, which will require fifteen to twenty minutes. Place the armature in such a position that there will be no pocketing of varnish in the winding or iron. When the armature is such as to require draining in other than a vertical position, turning will be necessary to avoid the gathering of varnish at one point, the amount of turning depending upon the general construction of the armature. It has been suggested that this draining can be done by spinning the armature in a lathe provided with a shield or cover to catch the surplus varnish.

After dipping and draining bake the armature in an oven at a temperature of 200 deg. to 220 deg. Fahr. until it is dry. This can be determined by taking the insulation resistance. For most cases the length of time given here will be sufficient to dry the armature: Below 12-in. diameter, forty-eight hours; 12-in. to 30-in. diameter, sixty hours; over 30-in. diameter, seventy-two hours.

Bake the armature in such a position that there will be no pockets of varnish when it is dry. In baking the armatures in a vertical position care must be taken in placing them in the oven so as to get free passage of air through the air ducts and around them. Ventilation is necessary to obtain the best results in baking. When an armature is so constructed that varnish will pocket when the armature is baked vertically, or in the case of dipping and baking with end bands in place, bake



Through an arrangement such as this the armature may be held in a convenient position for banding or tightening the coils while overhauling preparatory to dipping.

in a horizontal position. Such armatures are ventilated with radial air ducts. Armatures baked in this position should be turned during baking to avoid any gathering of varnish at one side.

After taking from oven, true up commutator face and neck, applying hoods at front and rear and the end bands. Fill hoods and coat surface by brushing on baking varnish. Place in oven to set varnish, applying as many additional coats as desired. Undercut the commutator and paint the armature with black air-drying insulating varnish, if a clear varnish has been used and a black finish is desired.

JOHN S. DEAN.

Motor Engineering Department,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

How Motor Speed Was Reduced Without Changing Horsepower

ORDINARILY the speed of a motor cannot be lowered greatly without at the same time lowering the horsepower. If the horsepower is kept the same the current per slot will increase in the same proportion as the speed decreases. If the current per slot increases the total cross section of the copper in the slot should be increased in proportion in order to prevent overheating. When the wires are packed closely it is often impossible to put more copper into the slot and this is the reason it is not possible to decrease the speed without decreasing the horsepower. Sometimes, however, a more compact insulation may be used and thus more room will be allowed for the copper. If the insulation is for a rather high voltage, some of it may be eliminated if the motor is rewound for a lower voltage.

A direct-current motor of which the speed could be lowered without affecting the power came into the shop not long ago. This was a case in which more wire could be squeezed into the slot. The motor in question was a ½-hp., 110-volt, 4-amp., two-pole, shunt-wound machine rated at 2,150 r.p.m. It was desired to keep the same horsepower and voltage but to change the speed to 1,700 r.p.m.

Now the speed of a shunt motor with constant field strength will change in inverse proportion to the change in the number of turns per armature coil. When the motor came in, the coils had thirty turns of one No. 22 double-cotton-covered wire. To decrease the speed, the number of turns had to be increased. The number of turns for 1,700 r.p.m. would equal $(30 \times 2{,}150) \div 1{,}700 =$ about 38 turns.

The current per turn must remain the same if the motor is still going to carry ½ hp. This means that the wire must be no smaller, provided, of course, that the wire is already carrying about the proper current for its size. In standard motors the wire is carrying about the correct amperage. Therefore, if the wire must remain the same in size, the question was: Can the slot accommodate the thirty-eight turns when originally it had only thirty turns? Fortunately, it was found by trial that thirty-eight turns could be put into the slot. In fact, using single-cotton-covered enameled wire it was found that No. 21 gage could be employed with thirty-eight turns per coil. This larger size was consequently used.

In fact a larger size than the original was desired because the ventilation at the lower speed would be poorer. Also the voltage drop in the armature would be greater with thirty-eight turns than with thirty of the same size. The pitch was left at 1 and 9, as it was before. This motor had eighteen armature slots and eighteen commutator bars.

In some cases instead of increas-

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ing the number of turns, the same effect may be obtained by increasing the chord factor. As an example, suppose a motor has thirty turns per coil and a chord factor of 85 per cent. The speed of this motor could be reduced say 10 per cent by increasing the turns in the ratio of 100 to 90, which would give thirty-three turns. Or the same result might be accomplished by increasing the chord factor in the ratio of 100 to 90 which gives 93.5 per cent chord factor. A combination of these methods can be used if desirable.

Detroit, Mich. A. C. ROE.

Equipment and Materials Needed for a Small Repair Shop

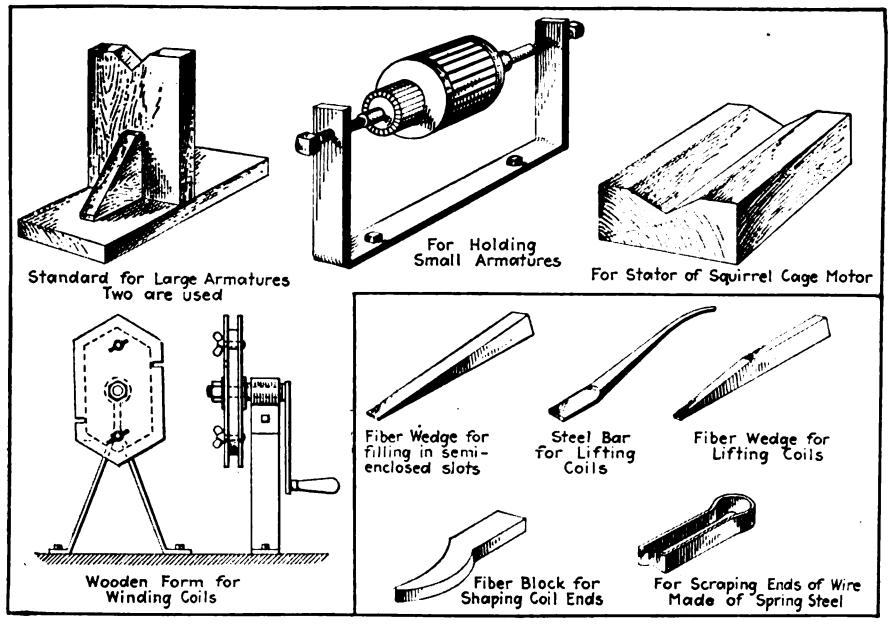
TWO things are necessary when starting up a small repair shop. The first is a certain amount of knowledge; the second is proper equipment. The few necessary tools required by the small shop are described in good books on armature winding. The number and type of tools will depend, to a large extent, on the kind and size of motors repaired. A large part of the equipment can be made in the shop. A small lathe will be found very convenient for turning down commutators, making small bearings and bushings, winding magnets and solenoids, and so on.

For holding large armatures while being wound, a standard is often used similar to the one shown in the accompanying drawing. A form of large C-clamp is often used for small armatures. For the stator of a squirrel-cage motor a V-block as shown will be found convenient.

Small stator and armature coils can be wound in a form held in one hand while the wire is fed with the other, but such an arrangement is very slow. It is quite an easy matter to rig up a form that can be turned with a crank.

A few hand tools will be required for shaping the ends of coils, filling the slots, lifting coils and driving and removing wedges. Some of these are shown in the drawing. Tools used for handling the wire directly should be made of horn fiber or some such material and all sharp edges should be removed.

The testing equipment of a small shop usually consists mainly of a growler, millivolt meter, a compass and a magneto. Some shops use only a magneto for testing for



Some useful tools for the repair shop.

grounds on low-voltage machines while others have special transformers for subjecting the windings to high-potential tests.

Regarding supplies, a small shop will find that single-cotton-covered enameled magnet wire will answer most requirements. Sizes from No. 14 to No. 30 should be carried. The amounts will depend upon the amount of work done and length of time required to receive material from jobbers. Often jobbers carrying a good line of electrical supplies have a very poor stock of magnet wire and other motor-winding material. In a small town where 50 to 100 motors, ranging in size from ¼ hp. to 15 or 20 hp., are wound per year and shipments of wire can be received from the jobber inside of three or four days, the following stock should be ample: 5 lb. of No. 30 to No. 27; 10 lb. of No. 26 to No. 20, and 25 lb. of No. 19 to No. 14. I realize that this is not a large stock, but one can "get by" with it.

The following stock of insulating materials will be found satisfactory: Cotton tape, ½-in. and ¾-in.; cotton sleeving; fishpaper, medium heavy; red rope paper, medium heavy; varnished cambric, medium heavy; red fiber sheet, 1/16 in. thick; slot wedges; varnished sleeving, about ⅛ in. diam.; insulating varnish, air-drying and baking; linotape, ¾ in. wide; varnished tubing, ⅛ in. inside diam.

We generally use a combination of fishpaper and varnished cambric, or rope paper and varnished cambric, with the cambric next to the coil for slot insulation. We often use a heavy varnished cambric for phase group insulation. Slot wedges can be bought from manufacturers, but very few jobbers carry them. We often have maple wedges made at a wood shop where a good jointer and circular saw are available. In this way we can get them the exact width and thickness required, and when we want them. With the exception of the varnished tubing, which is sometimes difficult to secure, all of the material mentioned in this list can be purchased from most jobbers. This tubing is not absolutely necessary for motor work but it makes a much better job of stator work and the like than does cotton sleeving.

For getting knowledge on how to repair, experience is the best teacher. This should be supplemented by school courses or study at home. It is well to practice on an armature or stator, using old wire or string.

If a shop is in business for itself the proper charge for repairing is a question which will be asked. The surest way is to find out what the nearby shops are charging. A few lists on motor-repair costs have been published. One will be found in Braymer's Armature Winding and Motor Repair (McGraw-Hill). Another will be found in the February (1922) issue of INDUSTRIAL ENGINEER. A very rough way to get at the cost of rewinding a squirrel-cage motor is to say that it will cost one-half the original cost of the motor.

J. P. COLLOPY.
Owner and Manager,
Motor Repair Shop,
Fort Collins, Colo.

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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Overcoming a Difference in Floor Level Between Buildings By Using an Elevator Instead of a Ramp

IT IS not uncommon in many plants, particularly those in which a modern addition has been added to an old building, to find a difference in floor levels which interferes with trucking from one department to another. The ordinary method of overcoming this difficulty is by building a ramp. There are two drawbacks to this method, however, in that ramps occupy considerable space and extend back into the plant if the grade is to be low enough to push trucks by hand. Even then helpers are usually necessary to boost heavy loads up the grade. Ramps also constitute a rather serious slipping hazard when taking loads down the grade.

To overcome a difference in floor levels of about 2 ft. the Economy Engineering Company (Chicago, Ill.) power-driven, portable electric elevator installation shown in the accompanying illustration was made at the plant of the Hygrade Lamp Company, Salem, Mass. Here, however, instead of leaving the wheels on the elevator and making it portable, it is placed in a pit so that the platform of the elevator is at the floor level as shown in the illustration at the left. The elevator motor is operated by the trucker from the platform through a rope control.

A simple, permanent elevator installation which overcomes a slight difference between two floor levels.

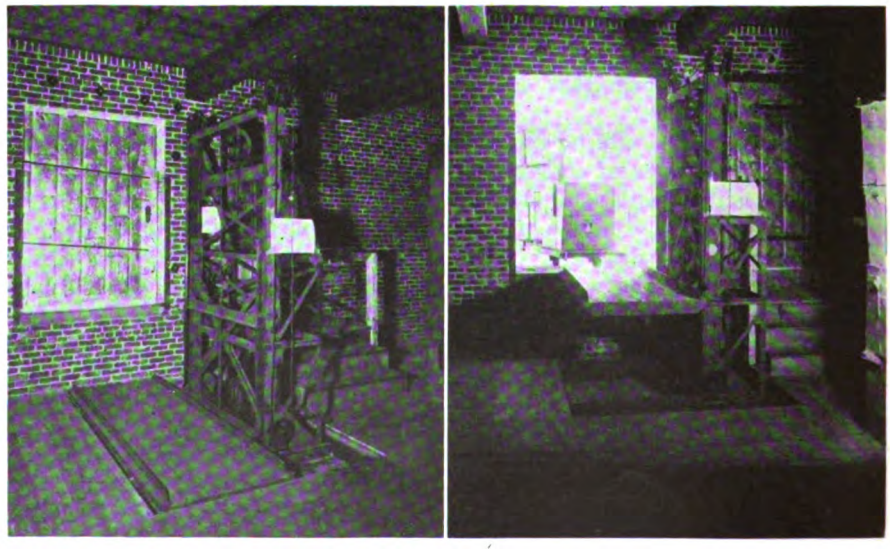
In cases such as this, portable elevators or tiering machines placed in pits afford a simple and economical method of raising and lowering truck loads between the two levels. This installation is not only power driven, but the operator can control its movement, through a rope while he is in a working position on the platform.

Installing a Conveyor to Perform a Complicated Series of Handling Operations

IN PLACES where material of a standard size is handled over any distance in large quantities at fairly regular intervals, it has often been found expedient to install permanent conveying equipment to do the work instead of using hand labor or truckers. Such at least was the experience of the Petroleum Import and Export Corporation of Louisiana, at its new plant on the Mississippi River, about 19 miles above New Orleans. The particular problems involved in this installation, in addition to those found in an ordinary industrial application of conveyors, were that the plant must be some distance from the wharf where the boats are loaded and that the loading is an intermittent but high-speed operation.

Here the petroleum products are exported in cans, two in a case. Three lines of gravity and chute conveyors carry the empty cases from the case-making department to the filling floor; another line of conveyors together with a spiral chute handles the cans to the filling machine, as is shown in the larger of the four illustrations accompanying this item. Cans are filled twelve at a time and packed two in a case, which is carried by a conveyor to the cover-nailing machine. They are then ready to be carried to the boat or to the warehouse until a boat is ready.

Because the docks must be placed in deep water it is necessary to carry the cases about 600 ft. from the warehouse to the dock, and along the dock to where the boat is standing. To do this, a double bridge conveyor, shown in the upper of the three small illustrations accompanying this item, was designed. The conveyors are arranged in two tiers. The upper tier consists for the most part of gravity roller conveyors wide enough to take two rows of oil cases. The lower tier consists of a run-way to carry barreled oil. The cases and barrels are filled on the ground floor and are raised to the proper conveyor by an inclined elevator and a barrel hoist.



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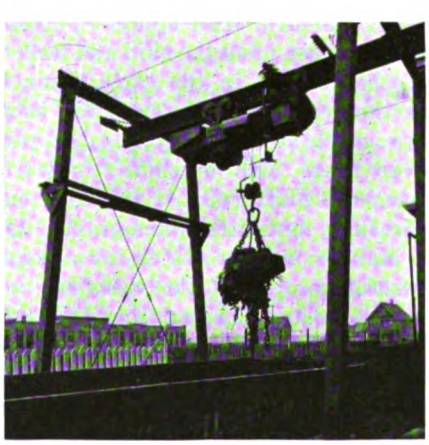


How packages are handled in bulk by conveyors instead of by hand.

The larger illustration above shows the three lines of conveyors carrying empty cases and a single line of conveyor and spiral which handles the cans to the filling machines. After the cans are filled twelve at a time they are packed two in a case and carried over another conveyor to the cover-nailing machine and are then ready for either the warehouse or go directly to the loading dock. The upper of the three illustrations at the right shows the bridge for carrying cases and barrels for the loading dock shown in the center illustration. The cases are transferred to cross belt conveyors which carry them lengthwise of the dock to the tower shown in this illustration. The spiral chute shown here suspended from the boom is lowered into the hold of the boat and lowers the cases by gravity.

The dock extends along the shore at right angles to this bridge. Cases and barrels are transferred from the bridge to the dock carrier conveyor which deposits them at the loading place along side of the boat as is shown in the second of the three photographs. The oil is carried to the loading tower at either end of the dock by one of two belt conveyors. The long boom on the tower is used to raise or lower the spiral conveyor, shown here attached to the boom, into the hold of the vessel. In actual operation, the cases are carried to this screw or spiral conveyor which lowers them into the hold, as shown in the third of the three accompanying illustrations, where the cases are distributed and piled. The cases are lowered to this spiral from the dock conveyor by gravity at low water; at high water a special booster elevates the cases to the top of the spiral to be lowered by gravity.

The savings which have been made by this installation are quite interesting. It would require a gang of fifteen stevedores to transfer from the dock to the ship 8,000 cases per day of 8 hrs. At present only one loading tower has been erected and one stream of cases is carried by the conveyor, which loads 1,800 cases per hr. or a total of 28,000 cases in an 8-hr. day, over three times the capacity of a 15-man gang. In addition, the conveying system carries these cases for the 600 ft. from the warehouse to the dock and along the dock to the loading point. If this were done by men with trucks it would require a gang several times as large as is used in loading to handle even the 8,000 cases per day over this distance, and in addition would require a large number of hand trucks or other types of trucks which would have to be kept in repair. Also, as this loading is intermittent work, the gang of men would be idle a large portion of the time, a factor which is conducive to high wages and often labor troubles. The Lamson Company, Syracuse, N. Y., designed and installed the conveying equipment.



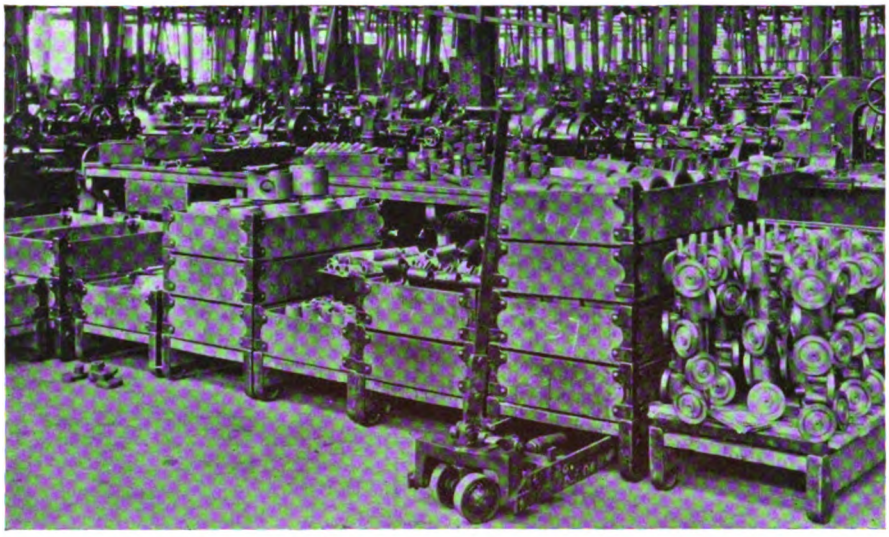
Three men with this hoist do in half a day the work which formerly took fifteen men all day.

Loading scrap into cars and handling 100 tons of steel plates a day do not occupy near all the time of this hoist. The 80-ft. runway allows the workers to distribute the steel over the storage yard. Wherever any considerable amount of metal is handled, it is well to investigate the adaptability of a magnet to do the work. The magnet and hoist do the kind of work that it is most difficult to get men to do in times of shortage of labor.

Magnet and Hoist and Three Men Do the Work of Fifteen-Man Gang

ONE OF the most difficult features of handling irregular shaped material, such as scrap or plate stock, lies in the difficulty of getting hold so that it can be lifted. For this type of work the Federal Pressed Steel Company used a magnet suspended from an I-beam, as shown in the accompanying illustration. This Pawling & Harnischfeger (Milwaukee, Wis.) two-motor type, pulpit control, 3-ton hoist is provided with a Cutler-Hammer (Milwaukee, Wis.) 43-in., circular lifting magnet. A 10-hp. hoist motor lifts at a speed at 35 to 75 ft. per min. A 6-hp. trolley motor gives a travel speed of 200 to 250 ft. per min. over an 80-ft. runway. The hoist operates on a 15-in., 42-lb., standard-section I-beam. The runway of the hoist passes over a concrete-lined pit, with a storage capacity of several carloads into which all sheet-metal scrap produced in the blanking, drawing and trimming operations is dumped. The magnet loads the scrap from pit to car in a few hours where formerly it required twelve men with wheelbarrows at least half a day. Also, as the scrap is dropped instead of dumped, it packs more into the car

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One method of building up skid platforms to handle machined parts.
Compartment skids built up in sections in the way shown make a flexible arrangement for handling machined parts as they can be used as a flat platform or a box truck.

and so obtains a better freight rate.

But loading scrap is an infrequent operation. The greater part of the work of this hoist and magnet is in handling about 100 tons of steel plate which is received in gondolas daily. Formerly, this required a gang of twelve to fifteen men to unload and place in yard storage. Now one man in the yard, another in the car, and the hoist operator will easily unload 100 tons in four or five hours, a saving of the labor of ten or more men daily. In addition to unloading the hoist also can be used to pick up from storage steel required in the shop.

How Special Skids Protect Delicate Machined Parts During Handling

AN IMPORTANT feature in all lift-truck installations for handling material in industrial work is the designing and use of the proper type of skids for the particular work involved in that plant. Each plant has its own problems and many have such a variety of problems that it is necessary to design several different types of special skids to handle all the work. The type of skid evolved for use in the plant of the R. K. LeBlond Machine Tool Company, Cincinnati, Ohio, is shown in the accompanying illustration. This skid consists of a platform and a number of sectional boxes which can be set up on this platform. The castings locking the corners are so placed that as these sections are fitted together they are locked to prevent their slipping off. In one case shown, this is built up four tiers high and, if necessary, could be built higher.

If desired, each of these sections may have a bottom in it so as to make a tray if the parts are so delicate that they should not be piled on each other. With extremely delicate parts which would be damaged by coming in contact with each other if piled in loose, it is sometimes necessary to make small compartments or sections or use some other device for dividing off the tray so that the parts are separated from each other. The method used for holding parts with a hole in them, such as gears and other cylindrical pieces, is shown in the stake attachment for the skid at the right. Here a flat platform with upright pins or stakes is set upon the skid and locked at the corners in the same manner as the sections. The parts, as they are machined, are simply slipped over these pins extending upward from the platform. If this is done carefully, but little damage results.

Many concerns which have kept careful records of the value of the parts damaged in handling through being piled loosely and bumping against each other, have found that special skids or trays for holding these parts separate from each other will pay their entire cost many times over in a short time. This is particularly true in cases where parts are ground to close dimensions or have finely finished surfaces or sharp corners which could be nicked or scratched, which in either case would result in damaging the parts so that they would be worth only their scrap value. The value of the metal in most cases is very low in contrast to the labor which is expended upon it. The lift truck installation in this case was made by the Steubing Truck Company, Cincinnati, Ohio.

How Two Electric Trucks Supplanted a 40-Man Gang

INCIDENTALLY with the adoption of better material-handling equipment in industrial plants the method of doing the work is also changed, which often results in additional and frequently unanticipated savings. For example, in one steel foundry it had been the practice to place the green cores on steel-framed, four-wheeled trucks and push them into the core ovens to remain during the baking. Often, due to the intense heat, the truck wheels would "set" on the hot axles so that it would be almost impossible to move the truck. In such cases the core-truck would have to remain in the oven until it cooled enough to be moved, and thus hold up the use of the cores as well as of the oven.

When electric elevating-platform trucks were installed at this work, heavy core racks were built which could easily withstand the high heat of the baking ovens without sagging out of shape. One of these racks loaded with cores for baking weighs about 3 tons and is picked up on the elevating platform of the electric truck, carried to and deposited in the oven. As it requires only a moment, the elevating-platform truck can either deposit a loaded rack of green cores or pick up the baked ones, even though the oven is still hot. This makes a considerable saving, as it is not necessary to wait until the oven is cool enough for men to do this work. Thus there are more baking periods because the time between bakings is reduced.

When removed from the ovens, the cores are taken to the foundry, a distance of several hundred feet. Before these trucks were installed, a gang of more than forty men was required to truck the cores, but now two electric elevating-platform trucks, with one operator for each, handle the racks much faster, and as there are no hold-ups in getting the cores out of the oven, a continuous production is assured. The saving of the wages of forty men would alone pay for the cost of the new equipment within a few days.

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Gears and Speed Reducers

(*Continued from page 136*)

horsepower sizes to very large units capable of transmitting several thousand horsepower, at almost any desired speed ratio, and designed for practically every class and condition of service. In addition to eliminating more or less completely the necessity for belting, shafting and open gearing, with consequent saving in space, the use of these speed transformers relieves the bearings on the motor or other prime mover of a good deal of pressure and wear, inasmuch as they are direct connected and therefore exert no side pull.

There are two general types of speed transformer. In one type use is made of a worm and worm gear; in the other type, spurs, or herringbone gears are employed. In either case the gears are enclosed in a tight, dust-proof housing which is partially filled with oil, so that all working parts are well lubricated, although the gears do not in all cases run in a bath of oil.

Spur gear speed transformers are usually of the planetary type, wherein the revolving pinions are mounted on plates supported on the high-speed shaft. At least one company is, however, marketing a non-planetary type of transformer in which the idler pinions are supported independently of the central shaft.

The installation and operation of speed transformers is about the same as for any piece of machinery.



Cut-a-way view of worm gear speed transformer.

The worm shaft usually runs at high speed and is mounted on radial ball bearings with thrust bearings to take the end thrust. According to the service the worm wheel shaft is mounted on plain, roller or ball bearings.

They are frequently mounted on the same base as the motor, to which they are connected usually by a flexible coupling. If they are not mounted on the same base as the motor, a solid foundation, preferably concrete, should be provided and the motor and transformer shafts carefully aligned. Whenever a gear, pinion, pulley or sprocket is mounted on the high or low-speed shaft an outboard bearing should be provided, to take the weight and side pull.

The only attention required by these speed transformers is to see that they are supplied with sufficient lubricant of the character recommended by the manufacturer. Oil gauges are usually provided to show the level of the oil in the reservoirs.

EDITOR'S NOTE: Acknowledgment is made to the following concerns for assistance in furnishing information and photographs for this and the preceding article: Boston Gear Works, Norfolk Downs, Mass.; The Chicago Rawhide Mfg. Co., Chicago, Ill.; Christiana Machine Co., Christiana, Pa.; The Cleveland Worm Gear Co., Cleveland, O.; The Falk Corporation, Milwaukee, Wis.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear and Machine Co., Chicago, Ill.; William Ganschow Co., Chicago, Ill.; General Electric Co., Schenectady, N. Y.; The Horsburgh & Scott Co., Cleveland, O.; D. O. James Manufacturing Co., Chicago, Ill.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Meachem Gear Corporation, Syracuse, N. Y.; New Process Gear Corporation, Syracuse, N. Y.; Niles-Bement-Pond Company, New York, N. Y.; R. D. Nuttall Co., Pittsburgh, Pa.; Philadelphia Gear Works, Philadelphia, Pa.; The Poole Engineering and Machine Co., Baltimore, Md.; Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Commutator and Brush Troubles

(*Continued from page 155*)

7. *Use of Lubricant on Commutator.*—When lubricant is used on a commutator it is usually applied to reduce either sparking or noise or both, but it is sometimes applied more from habit than from necessity. If the brushes are noisy there will usually be sparking due to the brushes jumping from the commutator and the application of lubricant will afford temporary relief. The same troubles can be permanently eliminated by a change in brush pressure, angle of brush operation (see paragraph 10, page 582, of the article by the writer in the December issue) or a change in the grade of brush. If sparking is present without noise, the application of lubricant may afford temporary relief by producing a comparatively high resistance film on the brush faces. Permanent relief should be sought by using brushes with a higher contact drop, the correct spacing of the brushes, shifting of the brush yoke, or trimming down the brush faces to span fewer bars.

The continued and frequent use of lubricant will cause commutator heating and a black commutator due to poor contact between the brushes and commutator.

If the brushes have any abrasive action or if sandpaper or commutator stones are used where the commutator has been lubricated, the oil or wax that has soaked into the brush will tend to collect the copper particles on the brush faces and cause a low contact drop and poor commutation.

8. *Dirty Commutator.*—By dirty commutator is meant one on which external dirt is allowed to collect rather than one which appears black or dirty due to sparking or the use of the wrong brushes. A dirty commutator will cause heating due to poor contact between the brushes and the commutator.

It will pay to wipe the commutator frequently with a clean dry rag or waste. If the dirt is too greasy to be removed with a dry rag it will be best to use two rags, a small one soaked in gasoline with a larger dry rag held just back of it to collect the dirt as rapidly as it is loosened and thereby prevent the dissolved grease from collecting on the brushes.

9. *Difference in Hardness of Bars.*—This trouble is hardly ever encountered on new machines because all the bars are made at the same time. But after a commutator has been rebuilt, the new bars are sometimes softer or harder than the old bars. If they are softer, flat spots are likely to develop and if they are harder the trouble will be high bars, which in turn will cause flat spots.

About the only satisfactory remedy is the use of a commutator stone as soon as either trouble appears. The sooner the remedy is applied the less work it will require to remedy it.

10. *Difference in Hardness of Mica.*—There is a great deal of variation in the hardness of different grades of mica. When a commu-

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tator is rebuilt the old mica left in part of the commutator and the new mica used between some of the bars may be different in hardness and the difference may be sufficient to cause uneven wear and result in flat spots. The best remedy for such trouble is to undercut the mica thereby eliminating its effect entirely.

11. *Commutator Not Properly Finished After Turning.*—After a commutator is turned, care should be taken to remove all burrs and tool marks with very fine sandpaper or a commutator stone. Improper finishing will cause commutator heating and rapid brush wear due to the rough copper surface.

12. *Commutator Too Small.*—This trouble is not often encountered in machines built by the manufacturer, but may be found when machines are rebuilt to operate at a lower voltage than that for which they were originally designed. The increased current may cause too much heating for the amount of radiation surface. The design of the machine may permit the installation of a larger commutator, but if not, it will be necessary to reduce the load or cool the commutator with a forced draft either by the installation of small fan blades on some part of the armature or commutator or by placing a fan to blow air on the commutator.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

W. A. Jones Foundry and Machine Company, 4401 West Roosevelt Road, Chicago, Ill.—A new edition of the Jones spur gear speed reducer catalog, No. 26, is now ready for distribution to superintendents, chief engineers, master mechanics or to anyone who specifies mechanical drives for factories, if they will request copies on business stationary and give their name and title. This catalog contains a large amount of technical and practical information, complete descriptive matter, and illustrations of typical drives, as well as dimensions, weight and horsepower rating for complete speed reduction sets.

Republic Flow Meters Company, 2200 Diversey Parkway, Chicago, Ill.—Bulletin S-12 on "Measurement of Steam" describes the use of Republic Flow Meters in the measurement of steam distributed to different departments.

The Esterline-Angus Company, 227 East South Street, Indianapolis, Ind.—Bulletin 1122, entitled "How to Make a Plant Survey," describes the purpose, method and the results obtained by the systematic use of graphic instruments in industrial plants. Some of the topics discussed are: What instruments to purchase; voltage and power factor; analyzing power cost; use of power; maintenance and the monthly power bill.

The Sherwin-Williams Company, Cleveland, Ohio—A 40-page booklet on Sherwin-Williams "Ajax" insulating varnishes and compounds discusses the fundamental characteristics of insulating varnishes and describes the various types of baking and air-drying insulating varnishes, acid-proof paints, cable varnishes, wire enamel and insulating compounds. Several pages are devoted to general directions for the use of these varnishes and some of the common troubles experienced in their use, as well as methods of testing insulating varnishes.

Zeller Lacquer Manufacturing Company, Inc., 342 Madison Avenue, New York City—A 30-page booklet entitled "250 Lacquer Questions Answered," discusses by the question-and-answer method the problems connected with lacquering. This will be distributed to those interested requesting same on the letterhead of their company and giving their official position.

Maroa Manufacturing Company, Maroa, Ill.—The Maroa portable belt conveyor is described and illustrated in a bulletin which also contains numerous suggestions as to possible uses for this equipment.

Henry Heil Chemical Company, 212 South Fourth Street, St. Louis, Mo.—A small folder announces an improved Bunsen burner which, it is claimed, burns like a blow torch without the use of compressed air. This may be used for soldering, welding, annealing metals, heating insulating compounds and other industrial purposes.

The Cleveland Armature Works Company, 4732 St. Clair Avenue, Cleveland, Ohio—Bulletin 303 describes the line of C. A. W. electric medium-duty grinders with direct motor drive. A sectional drawing shows the construction and various types of mountings—pedestal, bench and post types. A special shaft lock holds the shaft when changing wheels on the 2-hp., 1,800-r.p.m. and larger sizes and enables one man to change wheels. Bulletin 408 describes the line of electric buffers and polishers for the plating and metal-finishing room.

The Okonite Company, Passaic, N. J.—Recent literature announces "Okocord," a flexible cord designed for use in rough, wet or oily places in factories, shops or wherever it is necessary for the moment to carry power or light.

Frank Adam Electric Company, St. Louis, Mo.—Bulletin 26 describes the new Triumph panelboard type T-P (with tumbler switch and plug fuses). A particular feature of this is the unit construction. Numerous diagrams of various types of safety panelboards and cabinets are included.

The Black and Decker Manufacturing Company, Towson Heights, Baltimore, Md.—Catalog 5, entitled "Portable Electric Tools and Shop Equipment," describes in detail the construction of the Black & Decker electric drills, their construction and operation as well as including the prices of the various types of equipment. The section devoted to "How to Grind Drill Bits" describes the grinding and methods of testing the accuracy of sharpened drills so that they will give the best service in use. Other Black & Decker appliances described are bench and portable types of electric grinders and air compressors.

The O. C. White Company, Worcester, Mass.—Catalog entitled "White Adjustable Electric Light Fixtures for Applied Illumination" devotes 16 pages to the description of the various types of "White" portable lamps and lamp standards, ceiling fixtures, wall fixtures and portable lamp stands of various kinds.

E. C. Atkins and Company, Indianapolis, Ind.—A booklet entitled "Atkins Saws in the Shops" describes the various types of Atkins metal-cutting saws from hack saws to circular and friction saws, as well as band saws. A chart gives the proper speed, catalog number and description of different hack saws to be used to cut any of over thirty different materials. Another booklet describes the Atkins "Kwik-Kut" metal-cutting machine for both motor and belt drive. One of the special features of this machine is that it is claimed to automatically adjust the length of the stroke and use practically the entire blade at each stroke, with a corresponding saving of hack saw blades. Descriptions of the mechanical and electrical features are included as well as prices on the different sizes.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—A folder describes construction and gives the advantages claimed as well as a phantom view of the type NC squirrel-cage 40-degree induction motors recently announced.

The Alexander Milburn Company, 1416 West Baltimore Street, Baltimore, Md.—A 24-page booklet describes the Milburn welding and cutting apparatus, which includes acetylene generators of stationary and portable types and welding and cutting torches.

McGill Manufacturing Company, Valparaiso, Ind.—A vest-pocket folder entitled "The Efficient Guard" describes and illustrates the several types of "Loxon" lamp guards.

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APR 1923

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

April, 1923

McGraw-Hill Co., Inc. Chicago, Ill.

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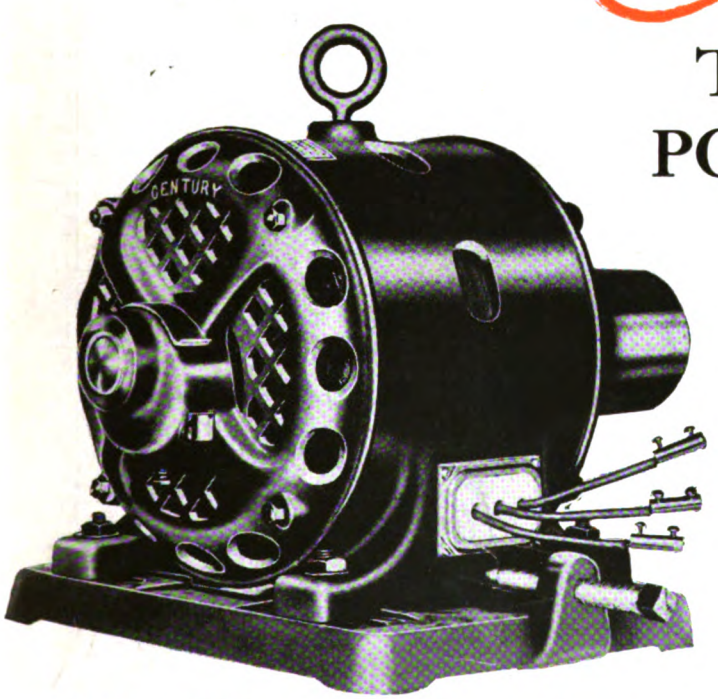
OVERMOTORING

Is Unnecessary

with

Century

Type "A. S." Induction POLYPHASE MOTORS



They Keep-a-Running

¶ A Motor of the correct horse-power rating for the running load usually produces sufficient static torque (not less than 180% of full load value) to meet the heavy starting demand of pumps, air compressors, refrigerating machinery, and other equipment producing a heavy inertia load.

¶ This result is accomplished with a starting current not in excess of 245% of full load. The period of starting is sufficiently short to permit the use of a fuse rated at 110%-125% of full load current rating. No current limiting starting device is necessary—a single throw switch will suffice.

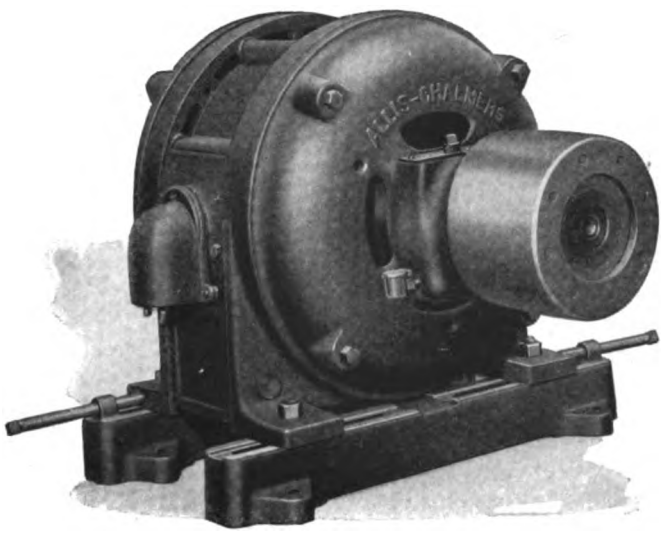
¶ The power factor of the starting current is high —75% to 85%. Temperature rise not more than 40° Centigrade.

Century Electric Company, St. Louis, Mo.

Sales Offices and Stocks in Principal Cities

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Polyphase Induction Motors

Constant and Variable Speed

60 and 25 Cycle

For All Standard Speeds

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Type AR Squirrel Cage Motor

A new Motor of new design throughout, taking full advantage of all improvements and advances made during recent years.

Type "AR" motors are designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.

Method of ventilation is very effective resulting in even cooling and avoiding of "hot spots."

Bearings are of liberal design with spacious oil-wells.

Insulation is of highest grade, stator being treated with baked on insulating varnish making the whole structure dust and moisture proof.

Motors are for floor or ceiling mounting being provided with very stiff and substantial rails.

Conduit terminal boxes are regular equipment.

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ALLIS-CHALMERS MANUFACTURING COMPANY

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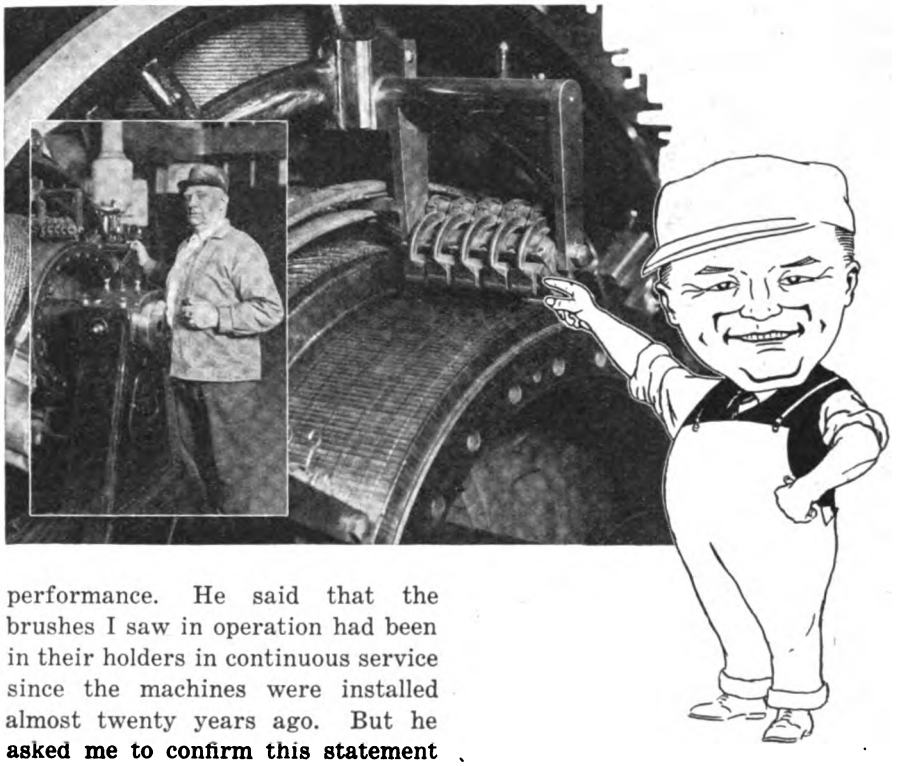
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, April, 1923 *Number 4*

These Brushes Have a 20-year Service Record

And here is the man who has kept his eye on them and made this remarkable performance possible



A FEW weeks ago while in Cincinnati, Ohio, I stumbled on to an interesting example of long and satisfactory service from four direct-current generators that carry a lighting load and operate elevators in the plant of the H. & S. Pogue Company of that city. In that plant I met a delightful gentleman who has lived with these generators since they were placed in operation and knows the meaning of every squeak and groan and just what these signals call for in the way of inspection and maintenance attention. He knows their language so well that there are no squeaks and groans except during such periods as he can get busy and apply the remedies that remove them. And when you talk to him as you stand by the side of these machines you do not have to shout your head off and he in turn has that quiet and low-pitched voice that goes with a mind as free from confusion and excitement as his machines are free from preventable noises—noises that are proof of inattention and undue wear.

While talking about these generators, Mr. Muntifer called attention to what seems to me to be a record for brush operation and commutator performance. He said that the brushes I saw in operation had been in their holders in continuous service since the machines were installed almost twenty years ago. But he asked me to confirm this statement through the makers of the machines. I did that and here is a letter from Mr. O. W. Jantz of Jantz & Leist Electric Company, Cincinnati, Ohio, that tells the whole story:

> We are in receipt of your favor of the 17th in reference to brushes used on the generators at the H. & S. Pogue Company's plant, this city.
>
> We are pleased to state that we shipped four 100-k.w., 230-volt, generators to the H. & S. Pogue Company on October 4th, 1903, and used ½ in. x 1½ in. x 3 in. Le Valley Vitae Carbon brushes. There are five brushes in each holder and six holders, making 30 brushes to the complete set for one generator.
>
> Up to date we have only furnished one complete set of brushes that their chief engineer, Mr. Henry Muntifer, ordered November 22nd, 1922, just for emergency so that he would have them in stock in case of need.
>
> These generators are operating ten passenger elevators, all their lighting system, and furnish the power required for operating ventilating fans, etc., and today we are pleased to report that they are in A-1 running condition. There is very little wear on the commutator or brushes.

Service in capital letters is modestly written all over this letter in the same way that it impresses you when you watch these machines in operation.

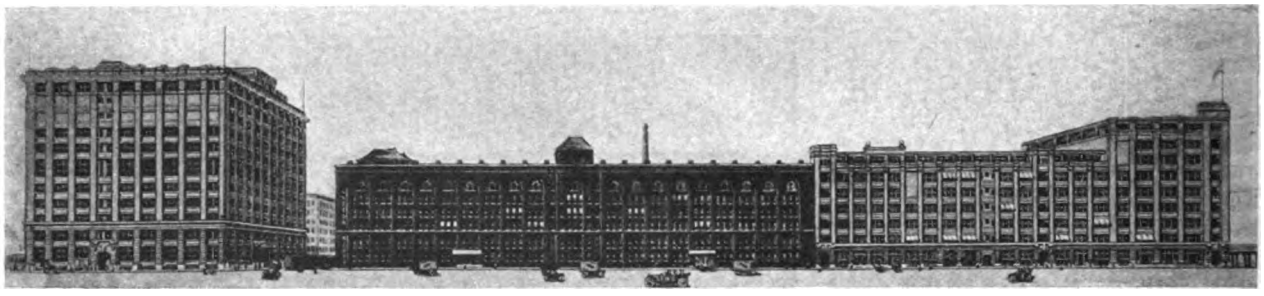
Other readers may be proud of installations like this one which stand as a credit both to the manufacturer and the operator from a performance viewpoint. If so, just drop me a line, giving the details—and then watch this page.

Practical Pete

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A Glimpse into the Works of
The National Biscuit Company

And the processes created by taking crackers out of barrels and putting them in small packages that go direct to the consumer. This is the fourth of a series devoted to the growth and extent of basic American industries.



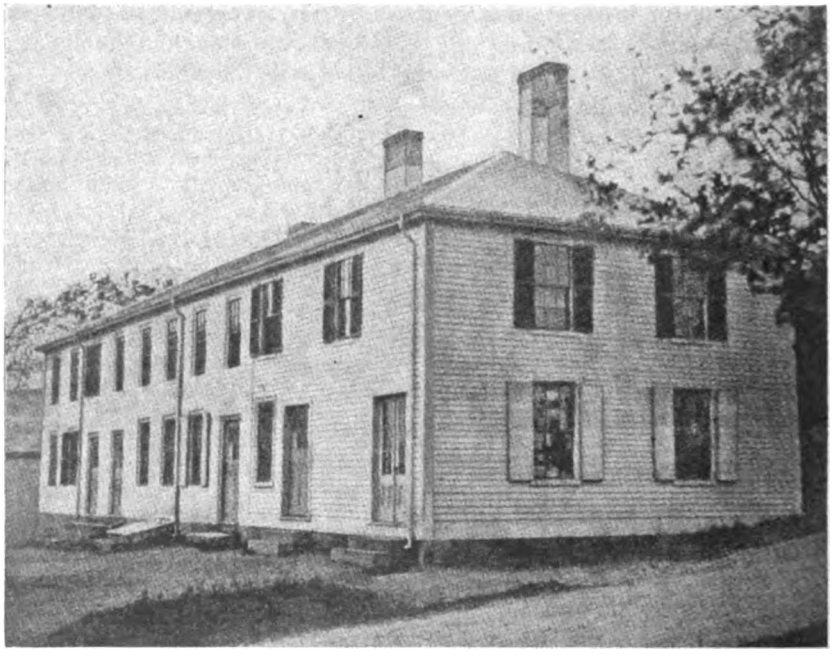
New York plant of National Biscuit Company—It has 53 acres of floor space and is the largest works in the downtown business section of New York.

OF THE basic industries which have made modern industries possible, probably the most important are the food industries. When each man had to grow, harvest and prepare the food for himself and his family, little time remained to enter into manufacture. Through the invention and perfection of the reaper, binder and other agricultural implements, as typified by the progress of the International Harvester Company in the February issue, and of the growth and extent of the milling industry, typified by the Pillsbury Flour Mills Company in the March issue, the modern industrial worker is assured of a continuous supply of food and so can devote his efforts to making shoes, clothes, automobiles, machinery, radio sets and other products to supply the necessities and diversions of himself and his neighbors.

This, the fourth of the series, carries the food industry one step further and takes up the preparation and distribution of a special food product.

When the National Biscuit Company was organized February 3, 1898, it was a great enterprise at the start with bakeries scattered throughout this country from coast to coast. This was brought about through the consolidation of the properties of the New York Biscuit Company, the United States Baking Company, the American Biscuit and Manufacturing Company and several smaller cracker-baking plants.

Today this institution operates forty-three plants that have 20,000 hp. in motors connected to machines. Besides the cracker-producing plants this company operates a molasses-blending plant in New Orleans to maintain the quality and uniformity of the molasses used. At Evanston, Ill., there is a large machine shop both for experimental work and the manufacture of machinery needed. At Marseilles, Ill., there is a large carton factory where all packages and bulk containers used in the marketing of National Biscuit Company products are made. In New York there is a completely equipped chemical laboratory with a large staff of chemists



Captain Bent's bakery in 1827.
The first unsweetened cracker (exclusive of hardtack) was baked by Captain Bent in 1801 in his home. This "bakehouse" was built in 1827 to accommodate increased demand. Practically the same process is used in some plants at the present day for making a certain kind of cracker.

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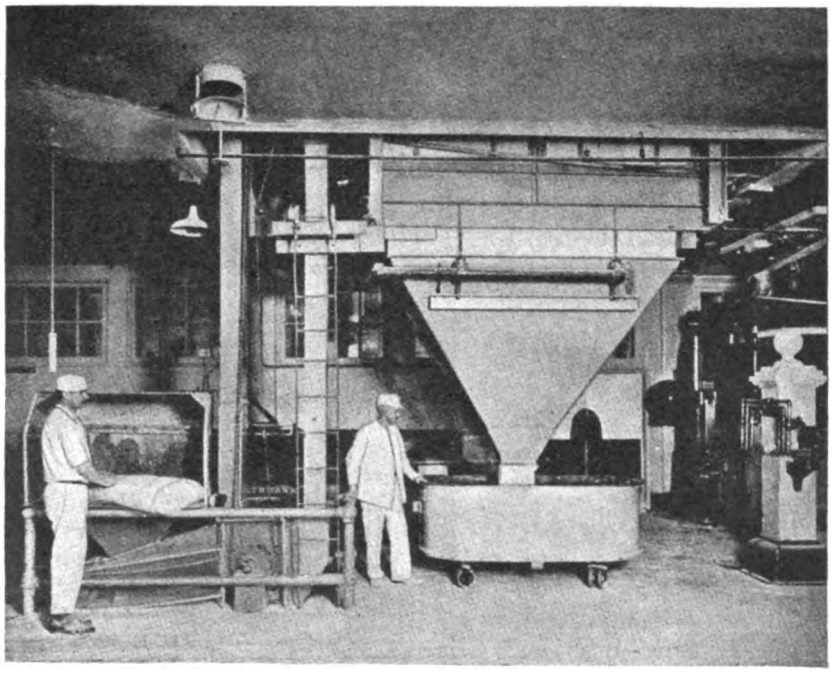


In this machine shop experimental work is conducted and special machinery built for cracker-making processes.

engaged in making tests and doing extensive research work.

This company has more than 2,000 salesmen working out of some 200 branch headquarters and calling on over 350,000 dealers with a fleet of trucks and wagons which, if lined up in single file, would cover a distance of eight miles.

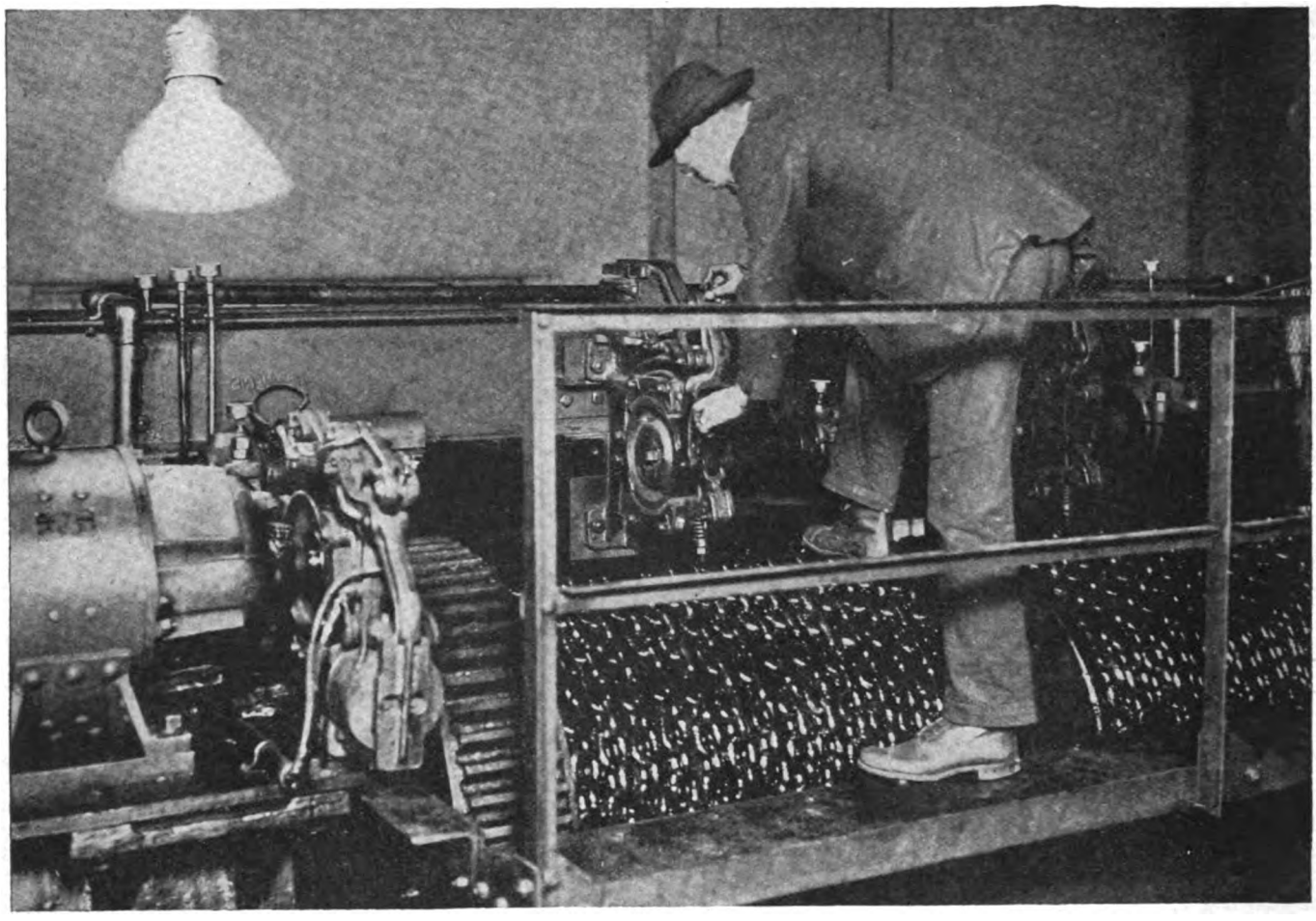
The National Biscuit Company during the past 25 years has revolutionized and evolutionized its business. It has revolutionized it by taking crackers out of boxes and barrels and putting them in packages and smaller, sanitary and scientific bulk containers, as a result of which they reach the consumer with full protection from oven to table. It has evolutionized it by the construction of special bakeries, scientific in design and construction and by the invention of machinery which does in a day the work which formerly would take a month to do manually. In all plants of the company specially designed and most ingenious modern machinery is employed in almost every operation. For example, automatic machines weigh, mix and sift flour, mix, roll and cut dough, and finally pack and seal the packages. One important step has been the creation of a most comprehensive distribution system, together with consistent and persistent nation-wide advertising. In this way the trade name "Uneeda Biscuit," which is known all over the world, has reached a value estimated at at least a million dollars a letter as a business asset.



Automatic machinery in a cracker factory.

This scene in a sponge-mixing department gives an idea of the ingenious machinery employed in making crackers At the extreme left of the picture is the hopper in which the flour is placed. It is carried from there automatically up and into the flour bolter and blender shown in the center. Here any foreign particles in the flour, such as a raveling from the bag, are removed and the blender aerates the flour and restores it to the condition it had immediately after it was ground. The flour is then fed into the dough trough, and automatically weighed at the same time. The trough is wheeled under the water controls at the extreme right. Here is filtered water, hot and cold. There is a gauge on the controls which indicates the amount of water as it flows, thereby assuring the exact amount of water called for by the formula. A thermometer attachment makes it possible to secure any temperature of water desired.

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The repairman is shown here inspecting the adjustments on the electric brake of a traveling crane.

Operating and Maintenance Practice for

Electric Traveling Cranes

Including Some Ways to Prevent Trouble and Prolong the Life of Parts Subject to Hard Service

By B. HANTMAN

Machine Repair Department, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

MAINTENANCE plays a very vital and important part in all industrial plants, especially in one of the size and scope of the Westinghouse Electric and Manufacturing Company. Production to a large extent depends upon a well organized maintenance department. It is the purpose of this article to deal with one branch of this work; namely, the maintenance of overhead electric traveling cranes.

The ideal crane equipment would be one in which only one standard make of crane was used, in which all the electrical equipment was supplied by one manufacturer, the same style and size of motors and control apparatus used on all cranes of the same lifting capacities, and the same wiring scheme used on cranes of like characteristics. Under these circumstances it can readily be seen that the variety of renewal parts to be carried would be reduced to a minimum, and that any electrical trouble could be readily diagnosed and then remedied.

AN INTERESTING feature of this article is the practice of making a "composite" casting from which any one of several parts which vary in size may be machined. This means that only one pattern has to be made, instead of several. Also the number of spare castings which must be stocked is greatly reduced. Other suggestions are given in this article on crane maintenance which can be applied in every-day work.

The Westinghouse Company does not have this ideal equipment, on account of having purchased its equipment at different times, extending over a number of years. At the East Pittsburg works alone there are 165 cranes, varying in lifting capacities from one ton to fifty tons, and representing the product of a num-

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ber of manufacturers. Since no two manufacturers build cranes alike, a large number of mechanical parts must be carried for renewals and repairs for these cranes, resulting in the tying up of considerable capital, and also of valuable floor space for the storing of these parts.

In order to overcome these conditions as much as possible the following plan is being carried out: (1) Drawings are made of all parts which are renewed or taken down for repairs. Two copies are filed, one under the crane number and one under the name of the part. For example, under Bridge Track Wheels, drawings of the bridge track wheels of all cranes, regardless of their capacities, are filed. (2) From the latter file the drawings are then grouped into several divisions, each division containing those drawings which show parts of the same general outline and dimensions. From these a combined or "composite" drawing is made for a casting, from which any of the parts in that division can be made. An example of one of these drawings for track wheels is shown in Fig. 1. The limit to which this practice may be carried is reached when the cost of machining the surplus stock becomes high, compared with the cost of making and carrying another pattern and casting in stock. (3) For bushings, a number of standard lengths of both solid and cored bronze stock of different diameters are carried in the storeroom. (4) Gear blanks of various dimensions are kept in stock.

The company's pattern shop and foundry are of material assistance in reducing the amount of spare equipment to be carried. To the former are sent the composite drawings from which patterns are made, these in turn being sent to the foundry for castings.

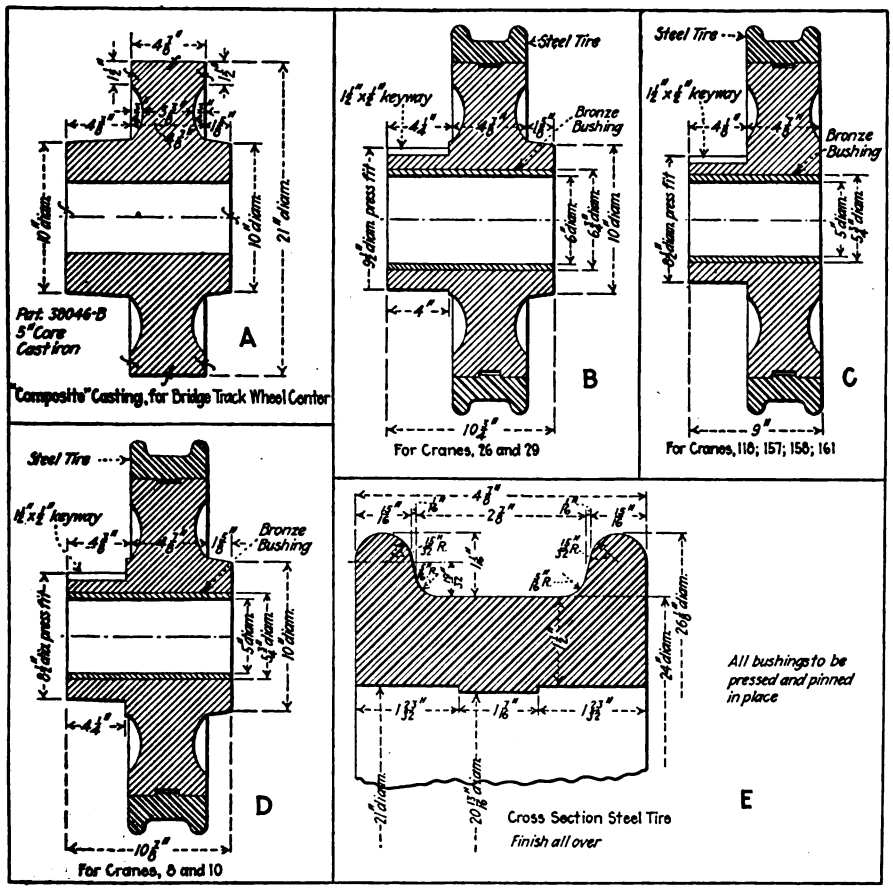
Troubles Encountered With Track Wheels

The majority of troubles encountered with the bridge of a crane is due to the track wheels. If the material in one of the driving wheels is softer than the other it will wear much faster, resulting in the soft wheel becoming smaller than the hard wheel. This causes the crane to run out of square, the end having the large wheel leading the other end. Running out of square is a serious defect, and must be remedied as soon as possible. When this condition is present the following results may occur: The crane binds on the runway; the bridge speed is reduced; joints in the bridge are loosened; joints in the rails on the runway become loose; the sides of the heads of the rails on the runway and the flanges on the bridge wheel cut each other; bridge-wheel flanges spread or flare; the bridge motor may stall and burn out; some part of the electrical circuit is damaged by overloading; and the trolley runs hard.

Flat spots occur on the tread of bridge wheels, due to soft places in the material and due to the operator applying his footbrake too quickly or plugging the bridge motor. These flat spots jar the crane and cause it to ride roughly. If the runway is not of the proper gage the bridge-wheel flanges will flare out, and in certain types of cranes will cut into the end trucks. The removal of a wheel in this condition is rather difficult, the flanges requiring either chipping or burning off with a torch, the latter method being much more efficient than the former.

Fig. 1—One casting serves for making any one of three different wheels.

The master casting at *A* is machined down to make the center of any of the wheels shown at *B*, *C* and *D*. Each of the wheels is equipped with the steel tire shown at *E*.



Wheels With Steel Tires Are Superior to Other Types

Other types of wheels are now being replaced with those which have a steel tire on a cast-iron center, as shown in Fig. 1. The center is used a number of times, inasmuch as the tire and bushing are the only parts that wear. The cost of the tire and bushing is much less than that of a new complete wheel. Also, such a wheel is superior to a cast wheel, because the tire is forged steel, having a more nearly homogeneous structure than a casting would have. This gives better wearing qualities to the wheel.

Bushings which are pressed into the center of the wheel may later become loose enough to turn, and for this reason they are pinned or doweled into place. Bushings may crush or work out at the ends, thereby forcing the wheels against the end truck. A cutting action between the two takes place, which may cause the crane to drag at this point. If proper lubrication is not supplied, the bushings will wear rapidly or may freeze on the shaft. When the tread of the wheel is considerably worn down the end truck may drag on the rail and the flanges may strike on the bolts of the rail splice plates. Any of these conditions will cause the crane to run out of square.

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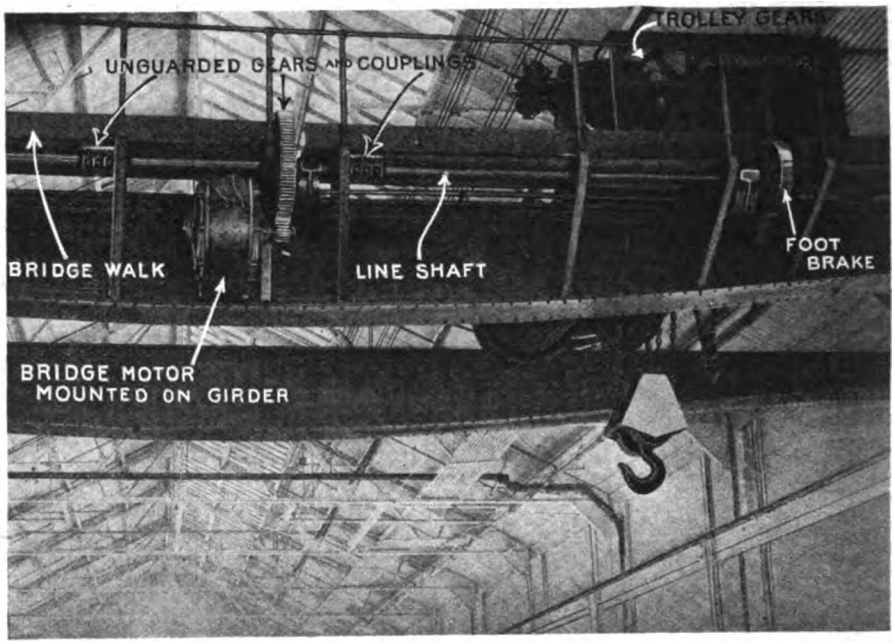


Fig. 2—This shows some common defects in a crane which was later remodeled.

Among the objectionable features which have now been removed are the following: Footwalk placed over lineshaft, bridge motor wall-mounted directly on bridge girder, footbrake acting on lineshaft, unguarded gears and couplings, electric solenoid band brake on hoist motor and inadequate guard over trolley gears. Some of the improvements made are shown in Fig. 3 and the other illustrations.

Where the shaft is pressed into the wheel when a bearing of the M.C.B. type is used, it has been found that this press fit is not reliable, the shaft having a tendency to work loose. To overcome this, the wheel is keyed onto the shaft, in addition to the press fit.

In some cases the wearing of the bushings or bearings will cause the gear on the track wheel and its driving pinion to mesh too deeply, while in other cases the mesh will not be deep enough.

Raising the End Truck to Change a Wheel

In removing a track wheel the end truck must be raised in order to take the weight of the crane off the wheel and shaft. The truck must be lifted high enough to permit the shaft to be rolled out and to allow for the larger diameter of the new wheel. This may be accomplished by running the crane up on two long wedges clamped to the rails, and then blocking it. When the wheel revolves on the shaft the shaft is first removed, then the wheel, and finally the wedges. Where the wheel is secured to the shaft the wedge is first removed and then the wheel with its shaft. After the old wheel has been replaced with the new one the wedge is then driven into position again and fastened, the blocking removed and the crane run off the wedges. The crane may also be raised by the use of a number of small steel wedges, by a jack placed on the runway, or by a jack on the floor with a timber reaching from the jack to the crane. In the case of a small crane, a chain block may be used. In any of these methods the raising is continually followed up with blocking as a precaution against a possible slip, and as a matter of safety.

On the bridge lineshaft the couplings, keys, gears, pinions, and bolts in the bearing brackets may work loose. The two end bearings and the one near the main gear which drives from the motor pinion are the ones subjected to the most wear. Rebabbitting or new brasses are required when the mesh becomes poor. A poor mesh between the lineshaft pinions and the gears on the track wheels may also be due to the springing away of the bearing bracket and lineshaft from the end truck, due to poor design. This may be overcome by fastening a brace from the top of the girder to the bearing bracket, as shown in the left-hand photograph in Fig. 6.

Bolts which hold the girders and the end trucks together work loose and may cause the crane to run out of square. On long spans it has been found advisable to place horizontal gusset plates between these two in order to make the bridge more rigid, as shown in the right-hand picture in Fig. 6. Rivets which have worked loose are replaced. The trolley rails, bolts and clamps become loose and, in extreme cases, the rails have sheared the bolts holding them in place. Occasionally the trolley-track wheels will wear a depression in the rails near the bumpers, causing the trolley to stick at this point. This is usually repaired by welding.

The footbrake has been found to be much more dependable and more efficient when placed on the arma-

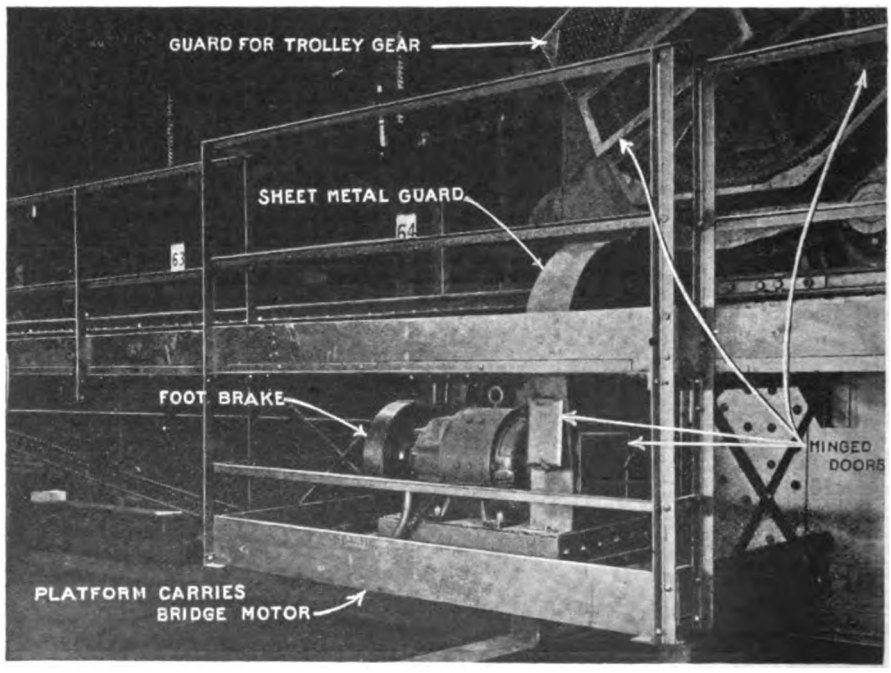
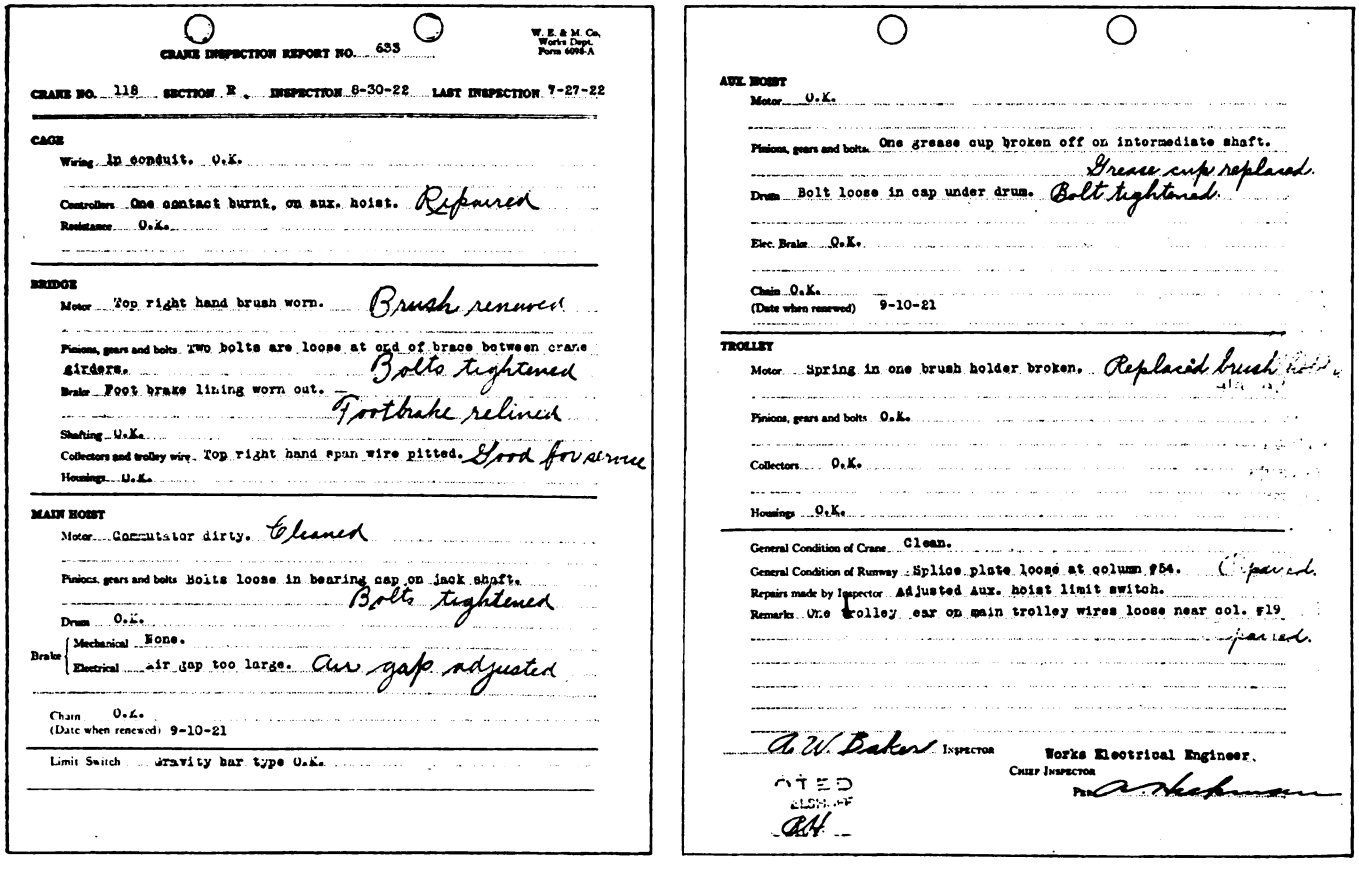


Fig. 3—Some desirable features have been added to this crane.

Among the improvements made on this crane are: Footwalk mounted under lineshaft, installation of standard metal railing and standard toeboards, bridge motor mounted on platform, footbrake changed to act on armature shaft of bridge motor, bridge gears protected by readily removable sheet-metal guard provided with hinged doors for inspection, and trolley gears protected by expanded-metal guard with doors.

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W. E. & M. Co. Works Dept. Form 6096-A

CRANE INSPECTION REPORT NO. 633

CRANE NO. 118 SECTION R INSPECTION 8-30-22 LAST INSPECTION 7-27-22

CAGE
Wiring In conduit. O.K.
Controllers One contact burnt, on aux. hoist. Repaired
Resistance O.K.

BRIDGE
Motor Top right hand brush worn. Brush renewed
Pinions, gears and bolts Two bolts are loose at end of brace between crane girders. Bolts tightened
Brake Foot brake lining worn out. Footbrake relined
Shafting O.K.
Collectors and trolley wire Top right hand span wire pitted. Good for service
Housings O.K.

MAIN HOIST
Motor Commutator dirty. Cleaned
Pinions, gears and bolts Bolts loose in bearing cap on jack shaft. Bolts tightened
Drum O.K.
Brake { Mechanical None. / Electrical Air gap too large. Air gap adjusted
Chain O.K.
(Date when renewed) 9-10-21
Limit Switch Gravity bar type O.K.

AUX. HOIST
Motor O.K.
Pinions, gears and bolts One grease cup broken off on intermediate shaft. Grease cup replaced.
Drum Bolt loose in cap under drum. Bolt tightened.
Elec. Brake O.K.
Chain O.K.
(Date when renewed) 9-10-21

TROLLEY
Motor Spring in one brush holder broken. Replaced brush
Pinions, gears and bolts O.K.
Collectors O.K.
Housings O.K.

General Condition of Crane Clean.
General Condition of Runway Splice plate loose at column #84. Repaired.
Repairs made by Inspector Adjusted aux. hoist limit switch.
Remarks Trolley ear on main trolley wires loose near col. #19 repaired.

A. W. Baker INSPECTOR
CHIEF INSPECTOR
Works Electrical Engineer.

Fig. 4—Report filled out and submitted by crane inspector.

ture shaft, as in Fig. 3, than when placed on the lineshaft, as in Fig. 2. When lined with asbestos brake lining this brake requires only an occasional adjustment or relining.

To facilitate the quick replacement of an armature, field coil or the complete motor, it is very desirable to have the bridge motor mounted on a bracket at right angles to the bridge girder, as shown in Fig. 3, instead of being wall-mounted directly on the bridge girder, as in Fig. 2. The platform mounting also has the added feature of safety for the repairmen. Bridge walks should be placed under, rather than over the lineshaft, so that the lineshaft bearings may be properly inspected, repaired and lubricated. Repairs to the lineshaft, couplings and gears are greatly expedited in this case. This practice is being carried out by the Westinghouse Electric and Manufacturing Company.

When there is more than one crane on a runway, it is very desirable and usually necessary to have one rail on the runway securely fastened and the other rail so fastened that it is free to move sideways in order to compensate for the slight differences in the gages of the various cranes and also to allow for the runway supports not being in true alignment. The play allowed in the loose rail is normally ¾-in.

Method of Replacing Trolley Track Wheels

On some makes of cranes, the trolley track wheels are mounted on the same shaft as the drum, the shaft remaining stationary. In the replacement of these wheels, it is necessary to block one end of the trolley so that it will not move while the other end is being raised either with jacks or heavy chain blocks. The shaft, drum and wheels are then rolled out from under the trolley. The wheels are now easily replaced on the shaft, and the shaft, drum and wheels rolled back into place. Care must be exercised in getting the shaft into its original position so that proper lubrication will be supplied to the wheels, and the shaft properly secured.

Bushings and gears wear of course and require renewing. Keys and bolts become loose and need tightening. Parts of the mechanical retaining brake such as discs, wooden friction blocks and other movable parts will wear and need occasional adjustment and proper lubrication.

Chains are annealed at intervals of one or two years, depending upon the service to which they are subjected, while the hooks on the blocks receive this treatment once every five years. When practicable, chains are being replaced by wire rope because the rope is safer and permits a more reliable inspection. The chains are frequently oiled to prevent a cutting action between the links and to reduce other wear to a minimum. Where equalizing bars are used the chains or wire rope must be cut to the same length. To eliminate the necessity for doing this and also to facilitate quick renewal of the chain or wire rope, the equalizing bars are being replaced with equalizing sheave wheels and a chain or wire rope cut in one length is used.

The blocks require proper lubrication and only an occasional renewal of a sheave wheel, hook or ball bearing.

The company's alternating-current cranes are being changed over to 250-volt direct-current as fast as they can be spared from service. These alternating-current cranes are supplied from 220-volt, 25-cycle, two-phase, four-wire and 220-volt, 60-cycle, two-phase, three-wire systems. The direct-current cranes are supplied by 250- and 500-volt circuits.

Due to the company's policy of giving all their new designs of apparatus a thorough and rigid test under actual working conditions before placing them on the market, we

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Fig. 5—Repairs made to crane are described on a report form like this.

REPORT OF REPAIRS TO CRANE ELEVATOR 161

Time breakdown was reported 4⁰⁰ P.M.

Time repairs were completed 5⁵⁵ P.M.

New parts supplied One 5 H.P. type H.K. trolley armature.

Detailed cause of repairs Commutator grounded.

Signed W. W. Householder. Date of Report 5-23-20.

Note—This form to be used by repairmen in charge of cranes or elevators in case of breakdown and all other repairs.

have a large variety of motors, controllers and other electrical equipment on the cranes. For example, there are eleven different types of direct-current motors varying in size from 1 hp. to 75 hp. installed. The old apparatus is, of course, replaced after the later and newer types have proven superior.

The electrical equipment may be roughly divided into the following sub-divisions: (1) Motors; (2) controllers; (3) resistances; (4) protective panels; (5) current collectors; (6) limit switches; (7) wiring.

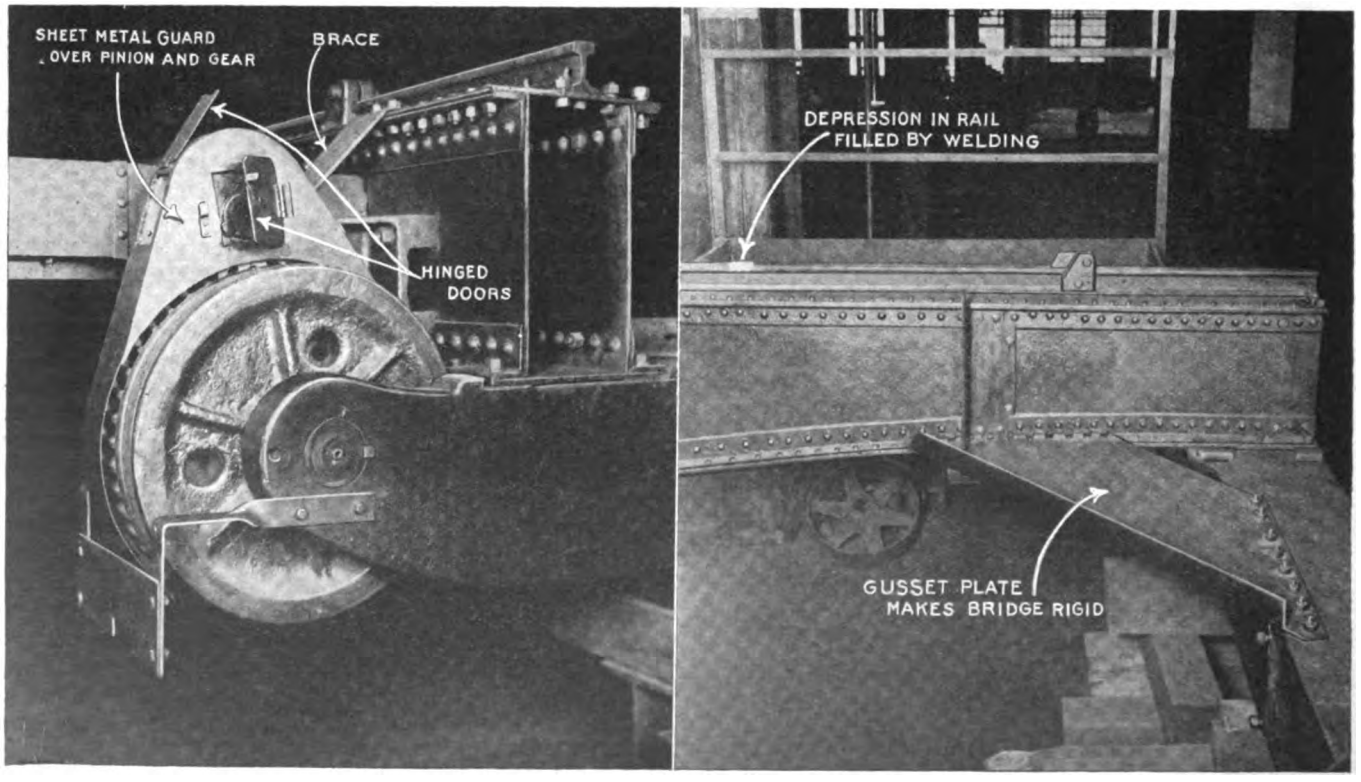
Whenever the type of motor to be used for crane service is being studied, the maintenance features should be considered as one of the deciding factors in reaching a decision, especially if a breakdown on the crane will delay production to any extent. If the shaft is tapered there is usually very little difficulty encountered in removing the brake wheel or the pinion; however, if the shaft is straight there is a possibility of breaking the keys while they are being removed, which makes matters worse and delays the repair work.

The controllers used on these cranes may be divided into four main types: (1) Commutator or grindstone; (2) face-plate; (3) drum cylinder and, (4), drum-contactor, (Type S). The chief objections to the first two are: size, weight, exposed contacts, arcing, which causes the screws to be welded to the contacts and delays renewals, grounds and creepage due to dust and dirt lodging between contacts, and difficulty of repair when placed close to one another. The troubles encountered with the drum type are: difficulty in keeping fingers in alignment with segments, arcing which causes the screws to be welded to segments, and burning off of the ends of the segments which interferes with the proper sequence of operation. All the above objections are eliminated in the cam-contactor type of controller. The drum consists of a set of cams mounted on a movable shaft, these cams actuating a number of contactors. The contactor tips require only occasional renewal, as they have a long life due to their rolling action.

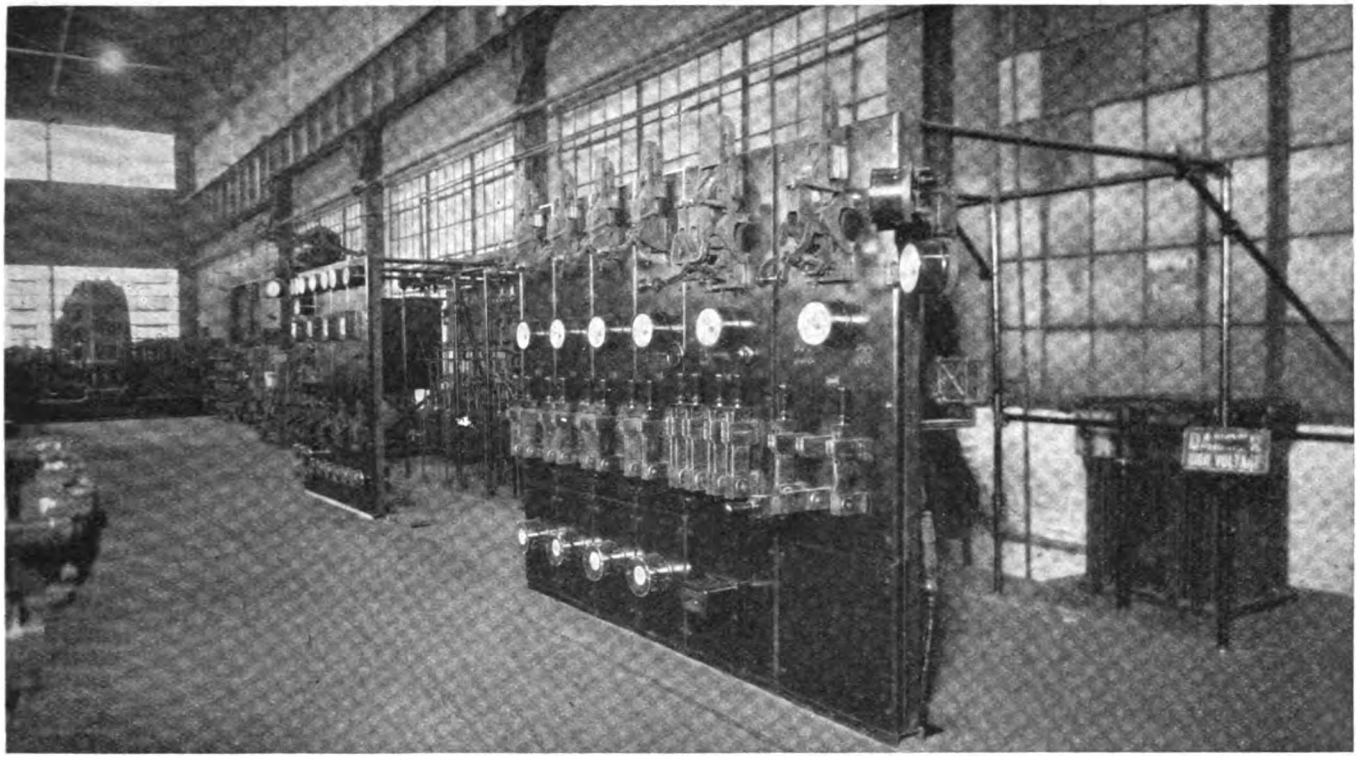
A number of the grindstone and the face-plate controllers have the resistance units mounted on the same frame; these resistances are either grid or wire ribbon. However, it is much easier to locate trouble when the controller and the resistors *(Continued on page 225.)*

Fig. 6—For inspection and repair the crane is run over a platform.

The illustration at the left shows the sheet-metal guard over the lineshaft pinion and the track-wheel gear. Hinged doors are provided for inspection and lubrication. The heavy brace from the girder to the end bearing insures proper meshing of the pinion and gear. In the illustration at the right is seen between the end truck and the girder, a heavy gusset plate which stiffens the bridge.



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This photograph shows the switchboard in the plate mill substation at the Mark plant of the Steel and Tube Company of America. It is typical of switchboards in ten other substations supplying energy to the various departments. This switchboard controls a 1000-kw. rotary converter, a fly-wheel motor-generator set and a reversing mill main motor.

An Analysis of Ways

Power Costs Can Be Checked and Distributed

Among Departments or Processes in Proportion to Amounts Required

By ARTHUR J. WHITCOMB

Formerly Assistant to Superintendent, The Steel and Tube Company of America.

POWER accounting in an industrial works is the distribution of power costs against the various departments or processes using the power and in proportion to the relative amounts of power used by the departments or processes.

What does this mean? Take for instance, a works where No. 1 alternator generated 500,000 kw.-hr., No. 2 alternator turned out 250,000 kw-hr., and 250,000 kw.-hr. were purchased from a public utility company, making a total of 1,000,000 kw.-hr. for the month. We now haul out our percentage sheet which says that at the time the sheet was made out, some three years ago, the Blooming Mill took 20 per cent of the total power, the Plate Mill took 25 per cent, the Blast Furnaces took 5 per cent, the Skelp Mill took 22 per cent, the Yards took 1 per cent, and the remainder should be charged to the Pipe Mills, for these mills take a lot of power anyway. From the total kw-hr. and the percentages, the charges against the different departments are made. That is what a power distribution is not! But this is a fair sample of what a power distribution amounts to in a great many industrial works.

THIS IS THE SECOND of four articles (the first appeared in the January issue) that analyze the essential factors of maintenance procedure. It deals with the auditing of power service requirements and tells what a proper distribution of power costs is and what it is not. The author points out that power in kilowatt hours represents dollars and cents of the same kind that go into the pay envelopes for labor. And for the same reason that the paymaster is not allowed to make an error of ten or fifteen per cent in figuring up his payroll, the method of accounting for power used should not permit such a range of guesswork.

Power in kilowatt-hours represents money and the same kind of dollars and cents are needed to pay for it as for any other material used in production processes. If power is purchased, the comparison is obvious. If it is generated on the plant property, it includes coal or gas, steam, investment costs, overhead, supplies, taxes and labor, all of which have very definite dollars-and-cents values.

An industrial works desiring true costs will not only pay attention to evaluating the total power cost, but also will insist that it is properly distributed, because an error there may make considerable difference in the production costs. This is particularly true in plant operations in which the power cost is a considerable portion of the total cost.

There are three essentials of an analysis of power distribution:

1. A true knowledge of the work of departments or processes

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among which the power is to be distributed.

2. A system of metering.
3. A system of checking.

The knowledge of the processes among which the power is to be distributed, can only be obtained by an intimate acquaintance with the processes involved and by conferring with the accounting department as to how it divides the rest of the costs. This division will vary with each individual works and mill.

For instance, in the Blooming Mill of one steel works, the power is distributed against:

1. Soaking pits and pit cranes.
2. Reversing main drive.
3. Auxiliary drives.

At the Blast Furnace of the works the power is distributed against:

1. Unloaders.
2. Ore bridge.
3. Skip hoist.
4. Larry car.
5. Pig machine.

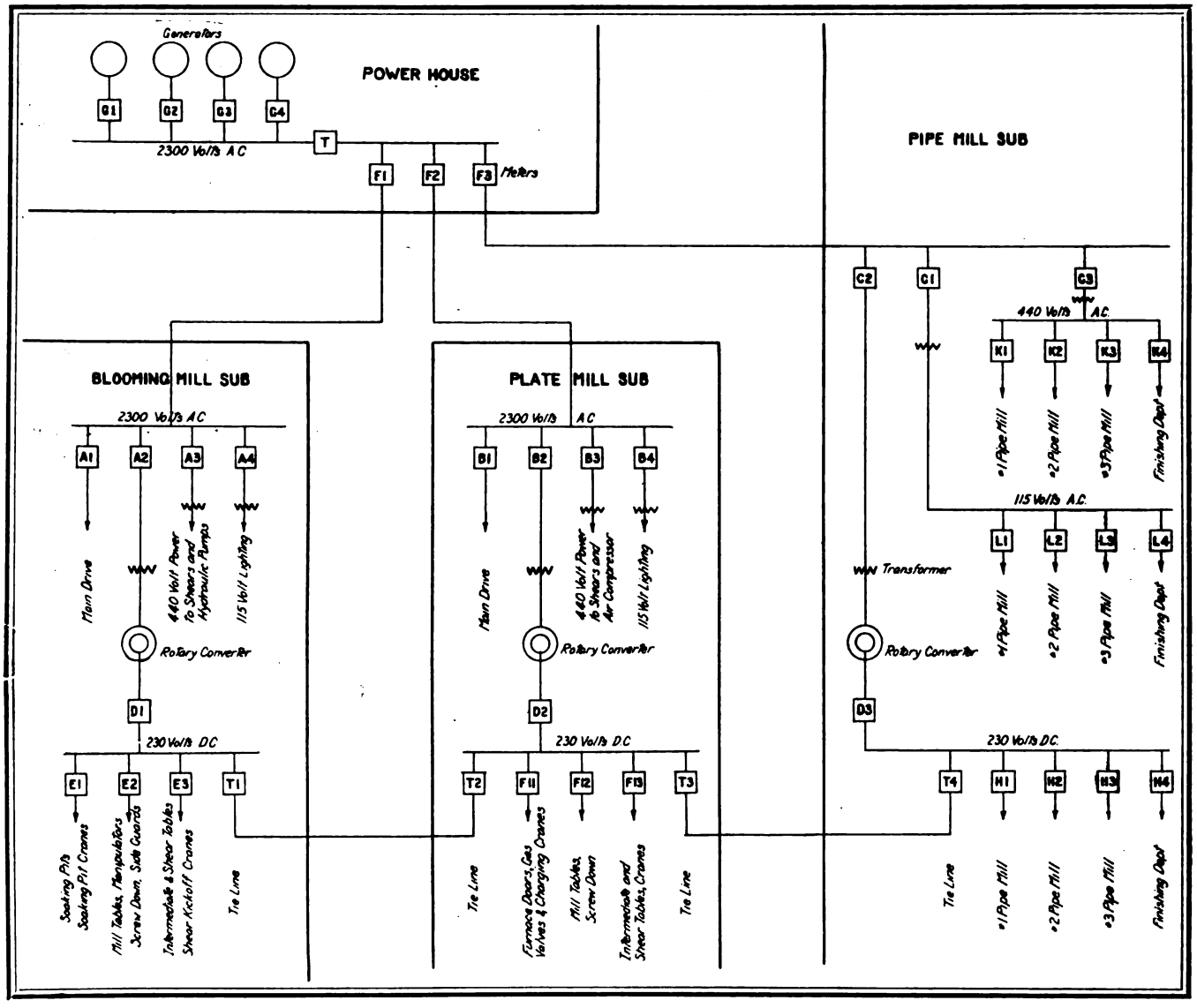
To show a good system of metering and meter checks, a power distribution system will be described for a works that has its own power generating equipment of 37,500 Kva. No power is purchased. Although the entire distribution system is not given in detail, enough is shown so that the details of the metering can be worked out.

Reference to the one-line diagram will show a power house with its generators feeding into a common bus from which go the feeders to the various substations. The power is generated at 2,300 volts, 60 cycle, and as such is transmitted over the feeders leaving the power house. At the substation the feeder supplies a common bus from which go the lines to the Main Drive motor, the rotary converter, the large auxiliary drives taking 2,300 volts, and the 440-volt and 115-volt power and lighting transformers.

The most important meters are those in the power house. It is these meters that determine the sum total of the power output. The diagram shows a watthour meter on each generator, a totalizing watthour meter, and a watthour meter on each of the outgoing feeders. The watthour meters on the outgoing feeders are essential for they measure the power output for each feeder. The sum of these feeder meters gives the total output. There are two methods of placing meters to check the total. One is by the use of a totalizing meter which will register the total output and the other is by the use of an

Paths through which power is furnished from generators to transformers and mill drives.

This single line diagram shows how metering is done on the electrical circuits throughout the works of the Steel and Tube Company of America. The diagram indicates the path of power from the generators to a common bus and through feeders to various substations. At the substation the feeder supplies a common bus from which go the lines to main drive motors, rotary converters, large auxiliary drives, and power and lighting transformers. The letters inside the small squares in these circuits indicate the points where power is metered.



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Form 10451 300 5-23*

THE STEEL AND TUBE COMPANY OF AMERICA

POWER HOUSE ELECTRICAL RECORD SHEET

DAY OF WEEK _____ MONTH _____ DATE _____ 19___

GENERATORS

TIME	VOLTAGE		UNIT No. 1			UNIT No. 2			UNIT No. 3			UNIT No. 4		
	BUS No. 1	BUS No. 2	BUS	WATT METER	FIELD AMPS	BUS	WATT METER	FIELD AMPS	BUS	WATT METER	FIELD AMPS	BUS	WATT METER	FIELD AMPS
8 A. M.														
7														
8														
9														
10														
11														
12 M.														
1 A. M.														
2														
3														
4														
5														

EXCITERS

TIME	VOLTAGE		UNIT No. 1		UNIT No. 2		UNIT No. 3		UNIT No. 4	
	BUS 1	BUS 2	BUS	AMPS	BUS	AMPS	BUS	AMPS	BUS	AMPS
8 A. M.										
7										
8										
9										
10										
11										
12 M.										
1 A. M.										
2										
3										
4										
5										

STATIC GROUND DETECTOR

TIME	BUS. 1			BUS. 2		
	A	B	C	A	B	C
8 A. M.						
7						
8						
9						
10						
11						
12 M.						
1 A. M.						
2						
3						
4						
5						

TOTALIZING

TIME	POWER FACTOR	FREQUENCY	WATT HOUR METERS	
			BUS. 1	BUS. 2
8 A. M.				
7				
8				
9				
10				
11				
12 M.				
1 A. M.				
2				
3				
4				
5				

FEEDERS

TIME	STATION FEEDER		BLOOMING MILL		BILLET MILL		PLATE MILL		SKELP MILL		GAS BOOSTERS		PIPE MILL		OPEN HEARTH		BLAST FURNACE		COKE PLANT							
	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER	BUS	WATT HOUR METER
8 A. M.																										
7																										
8																										
9																										
10																										
11																										
12 M.																										
1 P. M.																										
2																										
3																										
4																										
12 M.																										
1 A. M.																										
2																										
3																										
4																										
5																										

STATION FEEDER DISTRIBUTION

TIME	WATT HOUR METERS			
	440 VOLT POWER	BASIC PUMPS	COKE PLANT PUMPS	EXCITERS
8 A. M.				
7				
8				
9				
10				
11				
12 M.				
1 P. M.				
2				
3				
4				
12 M.				
1 A. M.				
2				
3				
4				
5				

Electrical Log or Record Form for Power Generated

This electrical record sheet is made out by the switchboard operator. It provides spaces for recording loads on generators and the bus to which each generator is connected. Spaces are also provided for other operating and switching conditions. This record is signed by the operators on duty during the period covered.

DELAYS OR SHUTDOWNS

CIRCUITS AFFECTED	TIME OFF	TIME ON	EXPLANATION

individual meter on each generator. If the steam input to the turbines or engines driving the generators is measured by a flowmeter on each generator, individual watthour meters on the generators are essential in order that the water rate or steam consumption per kilowatt hour may be determined. Comparisons of the water rate values as determined from day to day, will bring to light irregularities that might not otherwise be discovered until they had reached an advanced stage. The need for cleaning the condenser can be more easily determined for the water rate will increase as the condenser becomes dirty. Other things will come to light, for if the engineer gets a higher water rate than usual, he will hunt until he has discovered the condition causing it.

As stated before the total power output is determined by the sum of the power house feeder meters. If this value checks the sum of the generator meters or the totalizing meter, the meters are taken to be correct. These two sums should check within 2 per cent. If they do not, some meter is in error. Until the erroneous meter is located and corrected, the sum of the feeder meters is taken as being correct. Also the individual feeder meter readings are taken as being the correct output over the individual feeders.

From the one-line diagram it is seen that the generator meters are $G1$, $G2$, $G3$, and $G4$; the totalizing meter is T; and the feeder meters are $F1$, $F2$, and $F3$. Then to put the substance of the above paragraph in the form of an equation, the following is the result.

$$G1+G2+G3+G4=T=F1+F2+F3.$$

The input to the Blooming Mill substation is measured by the $F1$ meter. Reference to the one-line diagram will show that:

$$F1=A1+A2+A3+A4$$

If the sum of the A meters in the Blooming Mill does not equal $F1$, one of the A meters must be incorrect and until the faulty meter is located and corrected, the error in the sum of the $A1$, $A2$, $A3$, and $A4$ meters is divided proportionately among them until their sum is made equal to $F1$.

Similarly in the Plate Mill:

$$F2=B1+B2+B3+B4$$

And in the Pipe Mill:

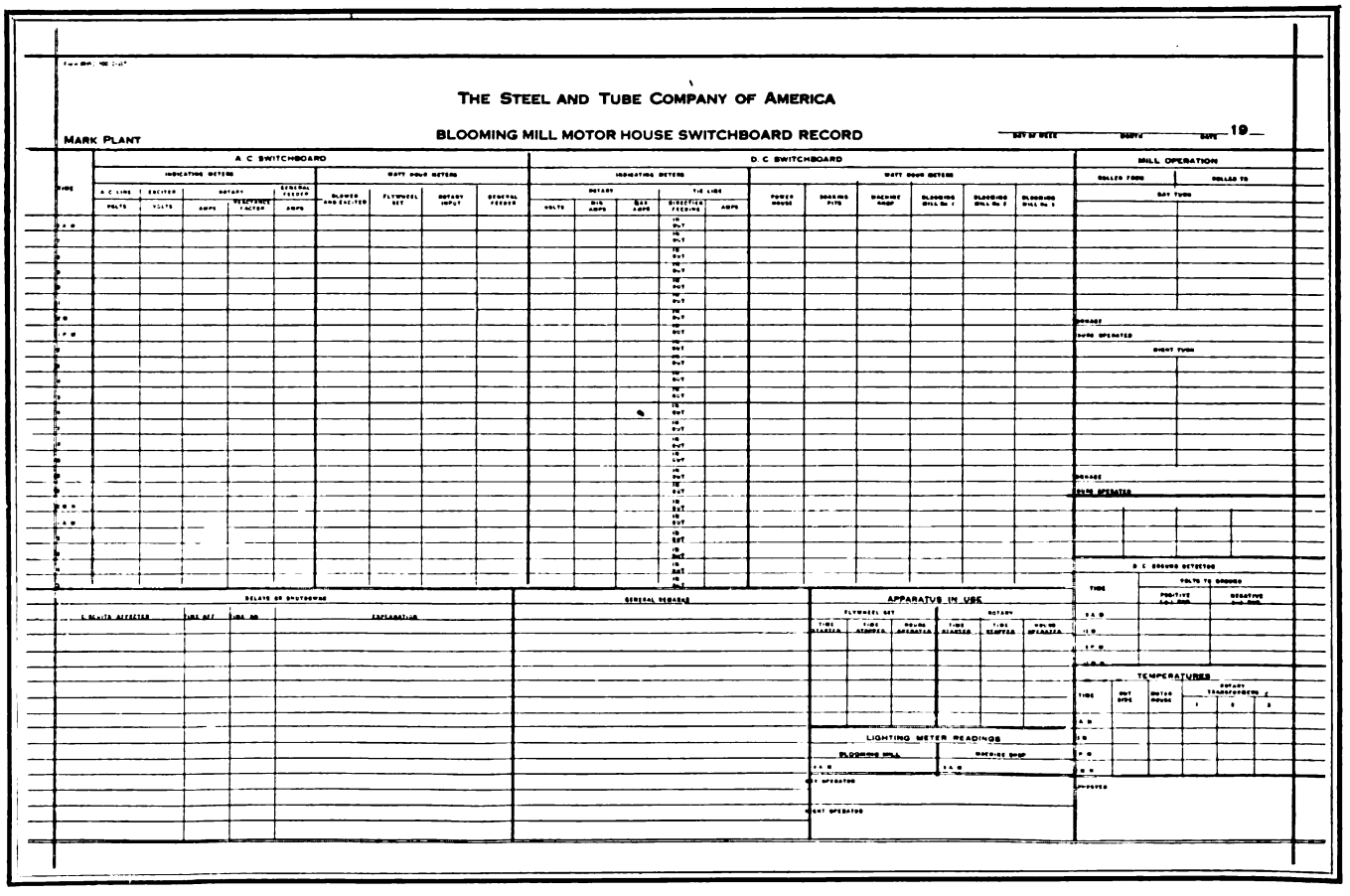
$$F3=C1+C2+C3$$

The one-line diagram shows a rotary converter in each substation. The rotary converters each supply a direct-current bus from which the individual mill feeders are fed. In addition there are tie lines between the substation d. c. buses. The d. c. output of each rotary converter is measured by the D meters. The T meters are on the tie lines between substations, and measure the power leaving the station on the tie line to which they are connected. These tie line meters have ratchets in them so that they will register the power flow for one direction only. For example, $T1$ measures the d. c. power going from the Blooming Mill d. c. bus over the tie line to the Plate Mill d. c. bus, while $T2$ measures the power flowing in the reverse direction from the Plate Mill Substation to the Blooming Mill Substation. Likewise $T3$ measures the power flowing from the Plate Mill to the Pipe Mill, and $T4$ the power from the Pipe Mill to the Plate Mill.

The Blooming Mill rotary output, $D1$, must equal the sum of the Blooming Mill d. c. feeder meters, plus the power leaving the Blooming Mill over the tie line, minus the power coming in over the tie line. The following is the equation:

Substation record form for power used.

These record sheets form the day book or journal of electrical operation and from them the ledger or power summary is drawn up. Besides showing the meter indications for the main drives, rotary converters and different mills, information is also given covering the character of material handled by the main drives and the causes for delays or shut-downs.



THE STEEL AND TUBE COMPANY OF AMERICA

MARK PLANT

BLOOMING MILL MOTOR HOUSE SWITCHBOARD RECORD

A. C. SWITCHBOARD

D. C. SWITCHBOARD

MILL OPERATION

DELAYS OF SHUTDOWNS

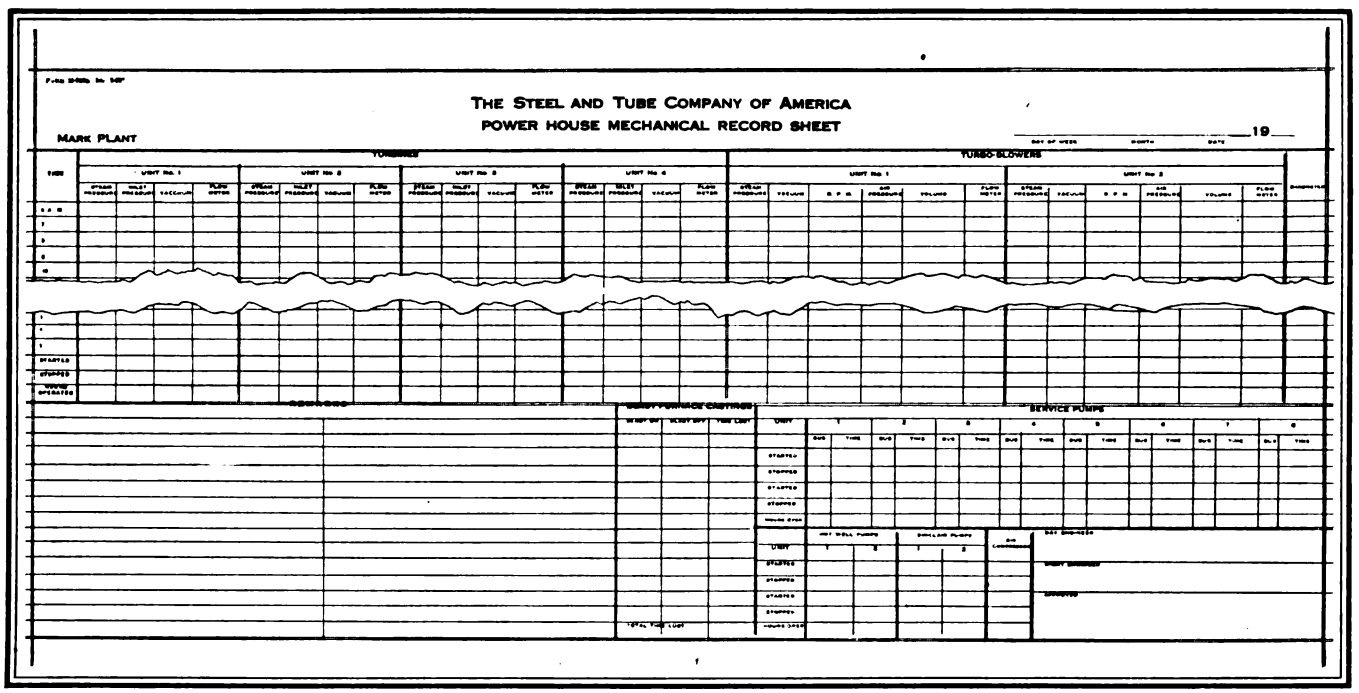
GENERAL REMARKS

APPARATUS IN USE

LIGHTING METER READINGS

TEMPERATURES

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THE STEEL AND TUBE COMPANY OF AMERICA
POWER HOUSE MECHANICAL RECORD SHEET
MARK PLANT
19

Mechanical log or record form for power generated.
This mechanical record sheet is made out by the turbine engineer and gives operating data on the station mechanical equipment similar to that covered in the electrical record sheet.

$D1=E1+E2+E3+T1-T2$

Likewise the Pipe Mill rotary output is:

$D3=H1+H2+H3+H4+T4-T3$

And the Plate Mill rotary output is:

$D2=F1+F2+F3+T2+T3-T1-T4$

In each case if the D meter does not equal the sum of the meters on the other side of the equation, the D meter is taken as being correct (until the faulty meter can be located and corrected) and the difference is divided among the remaining meters in proportion to their respective loads.

The conversion efficiency may now be calculated for each rotary. The conversion efficiency is the ratio of the d.c. output of the rotary converter to the a.c. input to the transformers supplying the rotary.

Conversion efficiency $=D1 \div A2$ for the Blooming Mill rotary.

Conversion efficiency $=D2 \div B2$ for the Plate Mill rotary, etc.

The conversion efficiency for all three rotaries is:

Eff.$=(D1+D2+D3) \div (A2+B2+C2)$

These values should be calculated each month and plotted on graph paper. Comparison of these values from month to month will help to show the most economical method of loading the rotaries.

The capacity factor is defined as the ratio of the total power actually converted to the total power that might have been converted, provided the machine ran at full load all the time it was in operation.

In the case of the Blooming Mill the capacity factor is:

$D1 \div$ (Full Load $KW \times$ No. Hours Run).

The capacity factor of all the rotaries combined is:

$(D1+D2+D3) \div$ [Full Load KW (of one rotary) $\times$ Sum of Hours each machine ran].

These values should be calculated each month and plotted on graph paper. Comparisons of these values over a period of time will throw further light on the most economical method of loading the machines.

At the plant described, the capacity factor for five converters supplying the steel plant load averaged 20 per cent, and the average conversion efficiency was 83 per cent. Curves as described above were plotted, and it was found that fluctuations in the values occurred. While the curves do not always lead to direct conclusions, still they form the ground work for the superintendent to think from in deciding upon the correct plan for the economical operation of his plant.

In the Pipe Mill Substation the 440 a.c. power is metered out on the 2300-volt side of the transformers by $C3$. The 440-volt feeders are metered by $K1$, $K2$, $K3$, and $K4$. Since the efficiency of the transformer bank is around 97 per cent at the ordinary working loads,

$C3$ will approximate $K1+K2+K3+K4$.

The difference between $C3$ and the sum of the K meters should be divided among the K feeders in proportion to their respective loads. The lighting feeders in the Pipe Mill Substation are treated similarly.

At first glance a system of meter checks, such as has been described in the foregoing, may seem superfluous and an extra expense for unnecessary meters. The reader may argue that if the meters are calibrated every two or three years, things will get along all right. They may and they may not—and in case an error develops it is not known at once and cannot be located unless all the meters in the plant are checked. The system described locates the erroneous meter as being one of a group of four or five, tells how much the error is, and gives the amount of error for each group of meters every month.

It may further be argued that the accuracy and exactness described is not necessary in an industrial plant—that if the meters come within 10 or 15 per cent it is close enough. Such argument is faulty. The "juice" going over the wires through the meters is dollars and cents, the same as put in the pay envelope to the labor employed in the mill. But the paymaster is not permitted to come somewhere within 10 or 15 per cent when making up the payroll.

The above analysis shows how the power was subdivided and how the checks were applied to make sure that the subdivision was accurate. It remains to summarize the results obtained. The summary follows:

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	Meters A. C.	Meters D. C.
Blooming Mill		
Main Drive.....	A1	...
Shear and Hydraulic Pump.....	A3	...
Lights	A4	...
Soaking Pits.....	...	E1
Auxiliaries at Main Rolls.....	...	E2
Auxiliaries at Shear	...	E3
Plate Mill		
Main Drive.....	B1	...
Shears and Air Compressor	B3	...
Lighting	B4	...
Reheating Furnaces	...	F11
Auxiliaries at Main Rolls.....	...	F12
Auxiliaries at Shear	...	F13
Pipe Mills		
No. 1 Pipe Mill...	L1+K1	H1
No. 2 Pipe Mill...	L2+K2	H2
No. 3 Pipe Mill...	L3+K3	H3
Finishing End.....	L4+K4	H4
Totals		
Total D. C.....		D1+D2+D3
Input to Rotary Converters	A2+B2+C2	
Total A. C...		F1+F2+F3

In the above tabulation the a.c. power is put in one column and the d.c. power in another, opposite the item against which it is to be charged. The amount of power is indicated by the symbol of the meter which measures the power being charged. As a final check on the work, the total of the d.c. column should equal ($D1+D2+D3$) and the total of the a.c. column plus the input to the rotary converters ($A2+B2+C2$) should equal ($F1+F2+F3$).

The above gives the power distribution in kilowatt hours. Before the charges can be made in the proper accounts the power must be evaluated in dollars and cents. The total a.c. power cost is taken as the sum of the following items:

1. Superintendence.
2. Power house operating labor.
3. Steam.
4. Water.
5. Repairs.
6. Supplies.
7. Line repairs.

The sum of these items divided by the output of the station ($F1+F2+F3$) gives the a.c. power cost per kilowatt hour.

The total d.c. power cost is the sum of the following items:

1. Superintendence.
2. Substation operating labor.
3. Repairs.
4. Supplies.
5. Cost of the total A. C. power input to the rotary converters (A2+B2+C2).

The sum of these items divided by the total d.c. output ($D1+D2+D3$) gives the cost per d.c. kilowatt hour.

The above costs are not total costs because they do not include the investment, depreciation, taxes and insurance costs. The costs which have been determined are what are known as operating costs.

Having found the a.c. and d.c. kilowatt hour costs, the power summary may be evaluated and the proper charges made.

A log or record sheet is made out each day for each power house and substation. These are of value for the following reasons:

1. They provide an hourly record of the load on the generators and of the output over the individual feeders.
2. They provide a daily record of the machines in service.
3. A record is made of all switching operations.
4. It insures that the operator makes an inspection of each meter at least once an hour and thus forcibly brings to his attention any irregularity that might develop.

Copies of the record sheets used in the power house are shown. The electrical record sheet is made out by the switchboard operator and the mechanical record sheet is filled in by the turbine engineer.

It will be noticed that on the electrical record sheet spaces are provided for recording the loads on the generators and the bus on which each generator is operating. The same is true of the exciters. There are spaces for the hourly readings of the feeder watthour meters and the totalizing watthour meter. Also a record is made of the station voltage, frequency, power factor, ground detector, and generator temperatures. A record is kept on this sheet of the time of starting and stopping the various units. Also all switching is recorded in its proper place. The record is signed by the operators on duty.

The mechanical record sheet is along the same lines, except that data is recorded concerning the turbines and the pump operation.

A substation record sheet is shown. On this sheet is recorded the operation of a flywheel motor-generator set operating the reversing main drive, a rotary converter, a motor-driven blower, a motor-driven exciter, a bank of transformers supplying the 440-volt power, and a transformer supplying the 115-volt lighting. Space is also provided for recording the size of material being rolled by the main drive. These record sheets form the day book or journal of the electrical operation, and it is from these sheets that the ledger or power summary is made.

A word should be said about the meters, for the meters are the backbone of the power distribution which has been described. The meters should be located in the middle or upper half of the switchboard so that they may be easily and accurately read. This location also gets them further away from the dust of the floor. In the case of the d.c. switchboards, however, it is necessary to put them in the bottom section of the switchboard, because the knife switches, indicating meters, and carbon circuit breakers take up the rest of the space. If the location is at all clean, glass covered watthour meters are recommended, because they enable the operator to give the meter a casual inspection without opening them.

A uniform scheme of connections should be adopted for each type of meter, and this scheme should be consistently followed throughout the plant. This is particularly important in the case of the a.c. watthour meters. Testing clips should be provided for the meters, and marked so that they can readily be identified. At the plant described in this article the pressure fuses for each a.c. watthour meter are marked *A*, *B*, or *C*, in yellow paint, to correspond to whichever phase the particular wire belongs. Likewise the current transformer leads are marked at the testing clips; *A* for the line side of the *A*-phase current transformer, *C* for the line side of the *C*-phase current transformer, and *O* for the common side of both transformers.

The system of meter checks described in this article will tell when testing of the meters is necessary. In general, however, it may be said that the a.c. meters should be tested at least once every two years, and the d.c. meters at least every year.

There are many ways of testing watthour meters, but for the ordinary industrial works, there is only one accurate way, and that is by the use of a portable rotating standard watthour meter. The portable rotating standard is connected in series with the meter under test and the tested meter's indication compared with that of the standard.

The third section of this article will take up procedure in an accounting of the work done by men in an industrial works responsible for the operation and maintenance of electrical and associated mechanical systems. The first section of this article appeared in the January, 1923, issue.

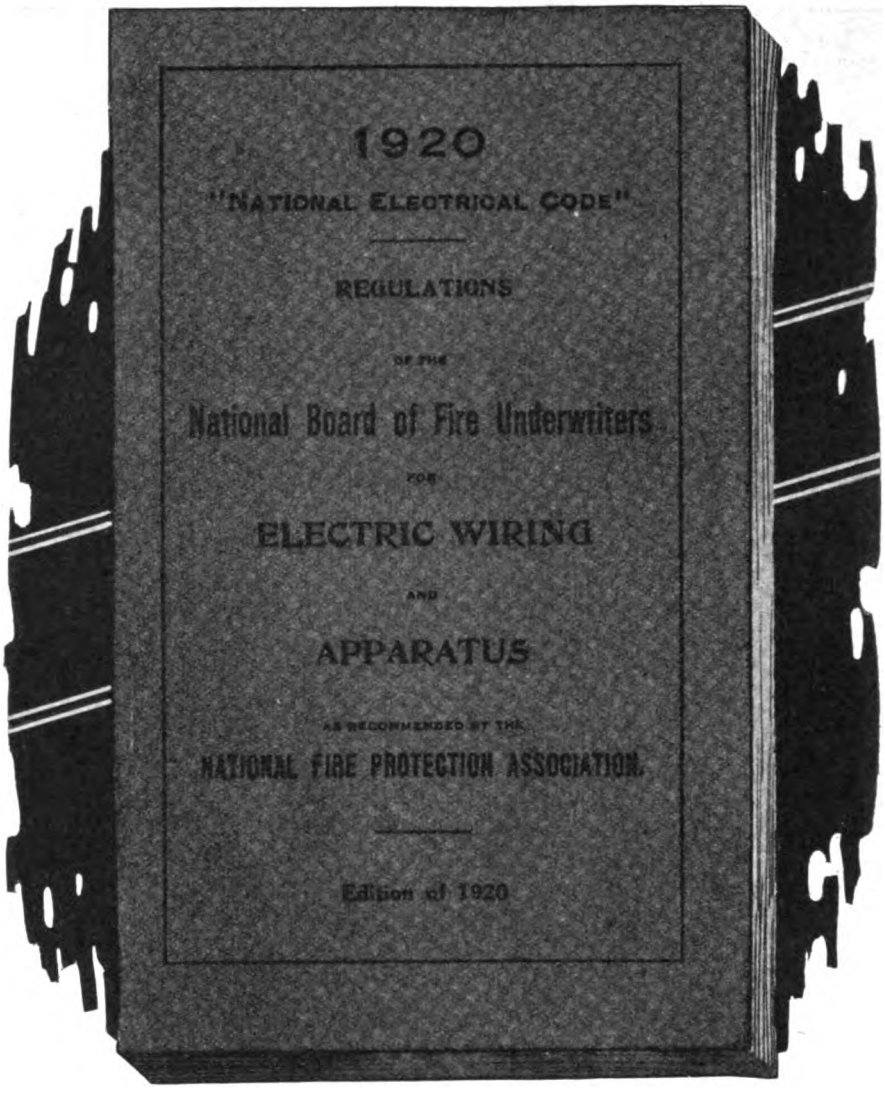
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Here Is a Summary of

Changes In National Electrical Code

Dealing with Motor Protection, Fusing Circuits, Grounds, Crane Wiring, etc.

By E. H. HUBERT
Associate Editor, Industrial Engineer



A NUMBER of important additions and changes in the National Electrical Code have been made by the Electrical Committee of the National Fire Protection Association. These changes embody proposals made to this committee during the last three years and the results of a public hearing in New York City on March 12. The changes in the code rules of interest to those doing industrial work refer to motor protection, the omission of fuses in neutral conductors and the use of 15-amp. fuses in 125-volt branch circuits eliminating the "600-watt" rule. A thorough revision is being made of the wording as well as the requirements of the code. This will not be completed for some time however. In the following paragraphs the most important of the changes are discussed. On the following page they are printed more fully with notations showing the old rules to which they refer. They may be used in this form to compare with the old rules.

More Liberal Rules on Motor Protection

Motors may be grouped under the protection of one set of fuses provided the rated capacity of the fuses does not exceed 15 amp. and the total wattage of the circuit does not exceed 1200, or the wattage may be of any value provided a thermal cut-out is used on each motor. The old rule set a limit of a 10-amp. fuse and 660 watts total.

Where circuit breakers are employed to protect a motor, fuses are not required provided that the fuse or circuit breaker next back on the line is set not above 300 per cent of the motor nameplate current rating.

Formerly when the over-load protection on a direct-current motor was shunted during starting, a separate set of fuses or circuit breakers was required for the motor. Now this set is not required provided the next overload protection (fuses or breaker) back on the line is set at not over 300 per cent of the motor current rating.

Overload protection may be omitted at the point where a branch for one motor taps the mains provided: (1) The branch conductors have a carrying capacity at least one-third that of the mains; (2) the length of the conductors from the mains to the motor protective devices is not over 15 ft., and (3) the conductors are protected against mechanical injury.

Every motor installed in a place where there is combustible dust in the air in sufficient quantities to produce an explosion must either be of the totally enclosed type or be placed in a ventilated dust-tight room.

No Fuses in Neutral by Permission

Where the secondary system is grounded at the service, the equipment, conduit, armored cable, metal raceways and the like may, by special permission of the inspection department having jurisdiction, be connected to the circuit-grounding conductor, but otherwise shall have a separate grounding conductor of its own.

The wrapping and soldering of wires to form a ground connection is not to be absolutely prohibited.

Unfused neutrals or ground circuits will be permitted on two-wire and three-wire branch circuits by permission of the inspection department. That is, omission of fuses in these conductors is allowed by permission. *(Continued on page 196.)*

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1923 Changes in National Electrical Code Rules

The italics indicate the additions in the 1920 edition of rules as amended

Rule 8c. Overload Protection of Motors. Amended to Read:

Motors may be grouped under the protection of a single set of fuses provided the rated capacity of the fuses does not exceed 15 amp. and the total wattage of the circuit does not exceed 1,200, or provided each motor is protected by thermal cut-outs. The number and size of the motors grouped with thermal cut-out protection need be limited only by the maximum size of the fuses with which the thermal cut-outs can be safely used, and each thermal cut-out must be marked to indicate the size of this fuse.

Fuses are not required in addition to circuit breakers (a) on main switchboards, (b) where otherwise subject to competent supervision, or (c) where next back on the line there are fuses rated or a circuit breaker set at not over 300 per cent of the motor nameplate rating, (d) for circuits above the capacity for which there are no standard fuses.

Where the motor-running protective device is shunted during the starting period the motor and the portions of the motor branch circuit between the motor and its running protective device are considered as being sufficiently protected during the starting period by the next overload protective device back on the line if the rating of this fuse or the setting of this circuit breaker is not over 300 per cent of the motor nameplate current rating.

Conductors carrying the current of only one motor must have a carrying capacity of at least 110 per cent of the nameplate current rating of the motor, *the actual size to be determined by the rating of the fuses or the setting of the circuit breaker protecting them.*

Automatic overload protective devices may be omitted at the point where conductors carrying the current of only one motor are connected to the mains, provided their current-carrying capacity is at least one-third that of the mains, the length of the conductors between the mains and the motor protective devices is not greater than 15 ft. and they are suitably protected from mechanical injury.

Rule 8f. Motor Switches. Amended to read:

In places where combustible dust is thrown into suspension in the air in sufficient quantity to produce explosive mixtures, such as in flour mills, grain elevators, etc., or where it is impracticable to prevent dust or flying material collecting in dangerous quantities on or in motors, all motors shall be either of the totally inclosed type or shall be placed in separate dust-tight rooms or non-combustible housings. Such rooms or housings shall be effectively ventilated from a source of clean air.

Rule 15Aj. Ground Conductors. Amended to read:

Where the secondary system is grounded at the service, the equipment, metal raceway and the like may, with permission of the inspection department, be connected to the circuit grounding conductor, but otherwise shall have a separate grounding conductor.

Rule 15Am. Switchboard Instruments. New section added to read:

Where meters and instruments are used with current and potential transformers, the cases of the meters and instruments may be connected to the secondary circuits of the current and potential transformers and grounded for the purpose of avoiding errors due to electrostatic action, in which case No. 12 B. & S. gage copper wire or larger shall be used for the grounding conductor.

Rule 23d. Fuses for Branch Circuits. Amended to read:

For the purpose of this section the terms "branch circuits" and "outlets" are defined as follows:

"Branch circuit" is that portion of a wiring system extending beyond the final set of fuses or circuit breakers protecting it, and at points on which current is taken to supply fixtures, lamps, heaters, motors and current-consuming devices generally; such points are designated as "outlets."

By special permission of the inspection department, two-wire branch circuits from systems having grounded neutral or one side grounded, and where the grounded conductor is identified and properly connected, may be protected by a fuse in the ungrounded wire, no fuse being placed in the grounded wire. Otherwise two-wire branch circuits shall be protected by a fuse in each wire.

Three-wire branch circuits may be run from direct-current or single-phase alternating-current systems having a grounded neutral, in which case the neutrals of the branch circuits shall not be fused. The neutrals of such circuits shall not be interconnected except at the center of distribution.

Branch circuits in general, and except as described below, shall be protected by fuses of no greater rated capacity than: 15 amp. at 125 volts or less, 10 amp. at 126 to 250 volts.

Fixture wire or flexible cord of No. 18 or No. 16 gage shall be considered as properly protected by 15-amp. fuses. Receptacles for attachment plugs (convenience outlets) are strongly recommended in order to facilitate the use of electrical appliances, which otherwise must be connected to sockets designed primarily only as lamp holders.

On a two-wire branch circuit and on either side of a three-wire branch circuit the number of outlets shall not exceed twelve except by special permission.

Branch circuits supplying only sockets or receptacles of the "Mogul" type shall have the wires protected by fuses having a rated capacity not greater than: 40 amp. at 125 volts or less, 20 amp. at 126 to 250 volts.

The number of "Mogul" sockets on a two-wire branch circuit and on either side of a three-wire branch circuit shall not exceed eight except by special permission.

Mogul sockets and receptacles and the fixtures with which they are used, shall be wired with conductors of not less than No. 12 B. &. S. gage. Taps from circuit wires to the points of suspension of such sockets, receptacles and fixtures shall not be over 18 in. in length *in order to be considered protected by fuses specified above.*

Rule 26a. Wires. Substitute for first paragraph:

For the conductor sizes No. 8 and smaller the neutral conductor on all three-wire circuits and one conductor on all two-wire circuits shall have continuous identifying marker readily distinguishing it from the other conductors.

Rule 28. Interior Conduits. b. Amended to read:

Concealed extensions from existing branch circuit outlets in buildings of fireproof construction, may be made by means of approved flexible or rigid conduit, not smaller than 5/16 in., or other forms of metal raceways approved for the purpose, and fittings containing one No. 14 B. & S. gage rubber-covered wire. This conduit is not to run in concealed spaces, but is to be laid on the face of the fireproofing and may be plastered over. Extensions of this kind shall be confined to the room or suite in which they originate.

Rule 43. Electric Cranes. c. Switches and Cut-outs. 3. Amended to read:

Where there is more than one motor on a crane, each motor *with its leads must be separately protected by an automatic cut-out in accordance with No. 8c, except that where two motors operate a single hoist, carriage, truck or bridge and are controlled as a unit by one controller, the pair of motors with their leads may be protected by a single automatic cut-out.* The cut-out should be located in the cab when there is one.

Rule 47. Primary Wires. Amended to read:

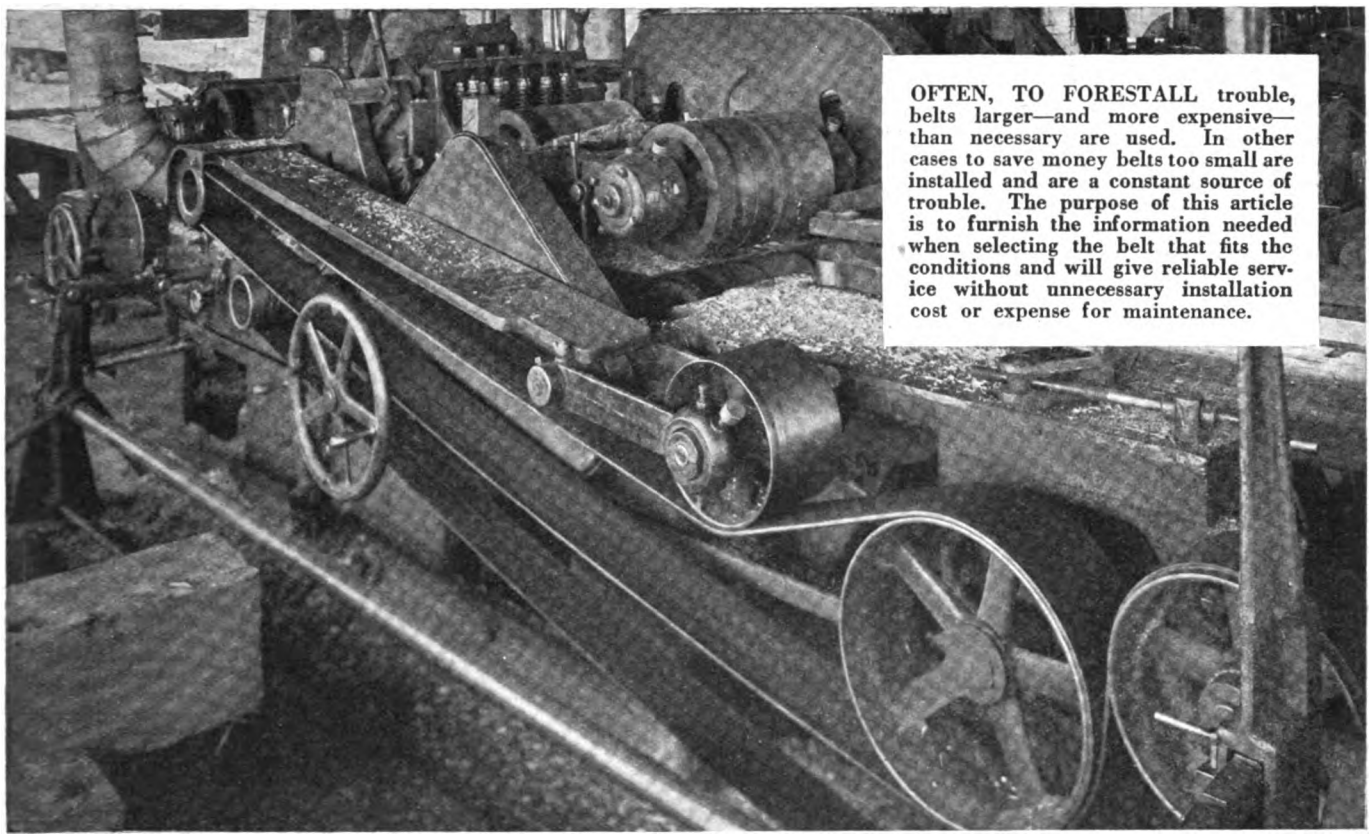
b. Air-break disconnectors shall be installed between oil switches which are used as service switches and the supply wires.

Rule 86a. Radio Equipment. For Receiving Stations Only. Amended to read:

Antennas outside of buildings shall be kept well away from all electric light and power wires for any circuit of more than 600 volts and from railway, trolley or feeder wires so as to avoid the possibility of contact between the antennas and such wires under accidental conditions.

Antennas where placed in proximity to electric light and power wires of less than 600 volts shall be constructed and installed in strong and durable manner and shall be located and provided with suitable clearances so as to prevent accidental contact with such wires by sagging.

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OFTEN, TO FORESTALL trouble, belts larger—and more expensive—than necessary are used. In other cases to save money belts too small are installed and are a constant source of trouble. The purpose of this article is to furnish the information needed when selecting the belt that fits the conditions and will give reliable service without unnecessary installation cost or expense for maintenance.

Side belts on wood planers operate under especially severe service conditions because of the high speeds and the relatively small pulley diameters. This is a leather belt made endless.

Some of the Allowances for

Operating Conditions Affecting Belt Service

To be Taken into Account When Ordering Belts for Industrial Uses

By FRANK E. GOODING

Associate Editor, Industrial Engineer

BELT TROUBLE would be largely overcome if more users insisted on ample pulley sizes for both motors and machinery. If a pulley is too small in diameter or too narrow it requires a heavier belt where a lighter belt, wider if necessary, would serve the purpose better. The work done in either case depends upon a fixed number of revolutions per minute, and with that factor constant, the only logical means of getting away from the evil combination of small, high-speed pulleys is to increase the size. In the majority of industrial drives, belts run at an average speed of under 2,000 ft. per min., whereas a more economical speed is between 3,000 and 4,500 ft. per min. It is possible in many instances to increase pulley diameters without any practical disadvantage to the machine design. There are, of course, cases where increasing the diameter is not practical, but a wider face and belt could be used. This would permit the use of lighter belts wide enough to handle the loads without having to be over-plied or extra heavy. Many times these problems are those of machine design and beyond the control of the belt user.

Short pulley centers and vertical drives work against efficient belt service; this is particularly true where either of the pulleys is small. The arc of contact, a direct factor in transmitting power, is decreased by short centers, except where an idler is used as in the well-known Lenix drive. In vertical drives, as shown in one of the accompanying sketches, the effective tension is reduced, excessive slippage, which may burn out the belt, results, and belt costs are greater.

The usual method of increasing the arc of contact, or regulating tension, is by using an idler pulley. While some forms of idlers are undoubtedly necessary for certain drives, it is fundamental that the additional flexing in the opposite direction from regular curvature demands increased belt flexibility often at the expense of belt life. In some cases the use of patent fasteners puts limitations on the use of idlers.

While recognizing that it is economical and often necessary to save floor space, it is also possible to lay-out the transmission so as to allow suitable pulley centers and avoid vertical drives. This calls for the intelligent use of jackshafts and countershafts to help avoid too great difference in pulley sizes. Wherever possible, it pays to eliminate quarter or half-turn drives. Also, it is not

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Determining Horsepower of Belting

For single leather belts every inch in width will transmit one horsepower for every 600 ft. of belt speed per min., double leather belts 50 per cent more.

It is impossible to give rules for horsepower that belting will transmit under all conditions. The following rules and tables will be found approximately correct providing the pulleys are of fair and equal size.

Doubling the diameter of the pulleys, at the same number of revolutions and with like contact of belting, doubles the horsepower of the belt.

Rule No. 1

To determine the width of belt required to transmit a given power at a given speed.

For single leather and 4-ply rubber belts.

Multiply amount of horsepower to be transmitted by 33,000 and divide the product by the product of the speed of the belt, in feet per minute, multiplied by 60. The quotient will be the width of the belt in inches.

Example—What is required width of belt to transmit 100 horsepower at a speed of 3,500 feet per minute?

$$\frac{100 \times 33{,}000}{3{,}500 \times 60} = 15\frac{3}{4} \text{ inches.}$$

For light double leather or 5-ply rubber belts

Multiply by 80 instead of 60.

For heavy double leather or 6-ply rubber belts

Multiply by 100 instead of 60.

For 6-ply rubber belt

Multiply by 120 instead of 60.

For 3-ply leather or 8-ply rubber belts

Multiply by 140 instead of 60.

Rule No. 2

To determine the amount of power a belt of given width will transmit running at a given speed.

For single leather or 4-ply rubber belts.

Multiply width of belt in inches by 60 and the product by speed of belt in feet per minute and divide the product by 33,000. The quotient will be the amount of horsepower that a belt will transmit with safety.

Example—How many horsepower will a 10-inch belt transmit, running at 4,000 feet per minute?

$$\frac{10 \times 60 \times 4{,}000}{33{,}000} = 73 \text{ hp.}$$

For other weights of leather belts or plies of rubber belts multiply by the same factors given in Rule 1 instead of by 60.

uncommon to use pulleys large and heavy enough to assist belts by their fly-wheel action to break the blow of sharp overloads with their momentum where extremely heavy duty is encountered. These are only a few of the service factors which should be considered carefully from both an initial cost and production standpoint in their relation to belt upkeep. Of course, it is to be expected that a belt of extra size, under proper operating conditions, will give less trouble. However, about 20 per cent of the cost of over-size belting may be attributed to motors or pulleys of the wrong size.

Selecting the Right Belt

When a new installation or alteration of existing equipment is planned the most suitable pulley and belt size may be selected to fit the particular requirements, after consideration of the service conditions. With pulley sizes and installations fixed, it is necessary to know what belt is best suited to meet the conditions. Before duplicating the previous belt installation it always pays to investigate its life and condition, particularly to see whether it is under or over-sized.

First, a belt (limited in maximum width by the pulley faces) must be chosen which will transmit the required horsepower. The most common error causing trouble here is in figuring on average rather than maximum horsepower. Reputable manufacturers allow a safety factor in rating the capacity of their belts. When a belt listed as capable of transmitting 100 hp. at a given speed is used to handle 150 hp., even intermittently, this overloading often reduces the actual utility of the belt to a point where it will not carry the load. Belts should be figured to the maximum power they will be required to handle, when possible. This should include the starting load.

The opposite fault (less noticed because it does not cause trouble in the shop) is over-belting. There is no sense in paying $100 for a 10-in. belt when a 6-in. belt at $60 is ample for the work and will last just as long. Often a belt is replaced in the shop by one much wider, merely to expedite production or to use up an old piece. When another is needed the wider belt is duplicated at an expense greater than necessary. Of the two evils, over-belting is the least expensive in the long run, but there is no excuse for doing so to the extent of adding unnecessarily from 20 to 100 per cent to the belting costs.

Most manufacturers of belting give a method of determining the horsepower for each of the types and grades of belting they list. In general, the horsepower transmitted depends upon the width of the belt, the speed and the tension of the belt, which is the variable factor. One

How to Determine Length of Belt

Rule No. 1

When both pulleys are nearly the same diameter:

Multiply one-half the sum of the diameters by 3.14. To this number add twice the distance (C.D.) between centers.

$[\frac{1}{2}(D + d) \times 3.14] + 2C.D.$ = length of belt.

Example—An open drive has a 24-in. and an 18-in. pulley. 15 ft. between centers.

$\frac{1}{2}(24 + 18) \times 3.14 = 66$
$15 \times 12 \times 2 = 360$
Length of belt $= 426$ in.
$= 35$ ft. 6 in.

Rule No. 2

When the two pulleys are of quite different diameters, to obtain the desired length, add A+B+C.

A=Multiply one-half of the sum of the diameters by 3.14.

B=Multiply the distance between centers by two.

C=Square the difference in diameter of the two pulleys and divide by four times the center distance.

Example—An open drive has a 6-ft. and a 24-in. pulley, 20 ft. between centers.

$[(72+24)\times 3.14]\div 2 = 151.$
$20\times 12\times 2 = 480.$
$(72-24)^2\div(4\times 240) = 2.5$
Length of belt $= 633.5$ in.
$= 52$ ft. $9\frac{1}{2}$ in.

Rule No. 3

For crossed drive to obtain the length of belt, add A+B.

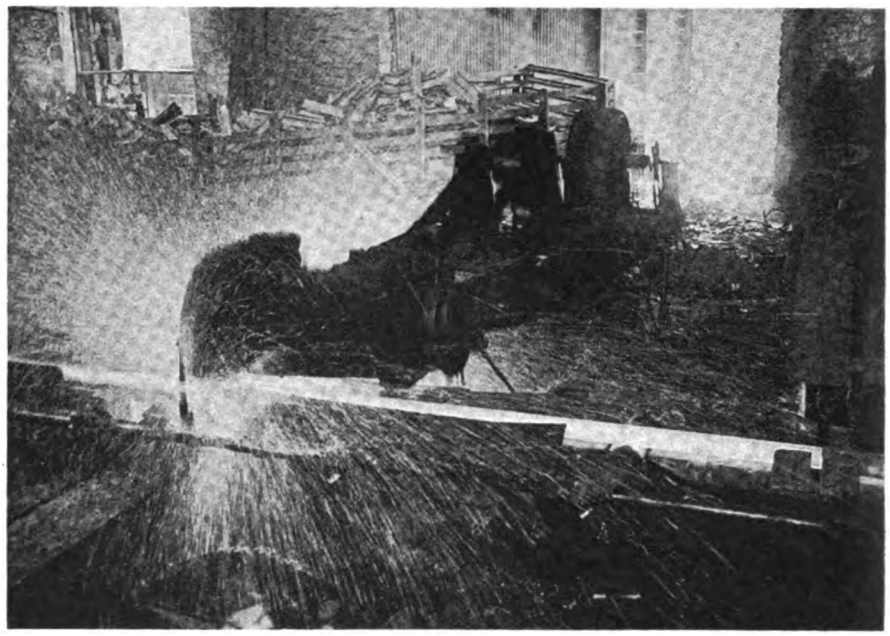
A=Multiply one-half the sum of the diameters by 3.14.

B=Square one-half the sum of the diameters. Add to this the square of the center distance. Extract the square root and multiply by two.

Example—A crossed drive has a 14-in. and a 16-in. pulley, 12 feet between centers.

$(14+16)\div 2\times 3.14 = 47.1$
$2\sqrt{[\frac{1}{2}(14+16)^2+(12\times 12)^2]} = 289.4$
Length of belt $= 336.5$
$= 28$ ft. $\frac{1}{2}$ in.

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Operating a hot saw is a particularly hard service for any belt.
Due to the high speed and intermittent shock loads a hot saw is a particularly punishing drive for a belt. In this case, the hot saw is belted directly to the motor by a Balata belt.

of the most common "rules of thumb" is that each inch in width of single-ply, light leather belt transmits 1 hp. for each 600 ft. per min. belt speed. Light double belt transmits about 60 per cent more than a single belt. One rule used is:

$$\text{Hp.} = \frac{\text{Width (in.)} \times \text{Speed (ft. per min.)}}{\text{Constant}}$$

One set of figures which may be used as a constant for different weights of leather belts is as follows:

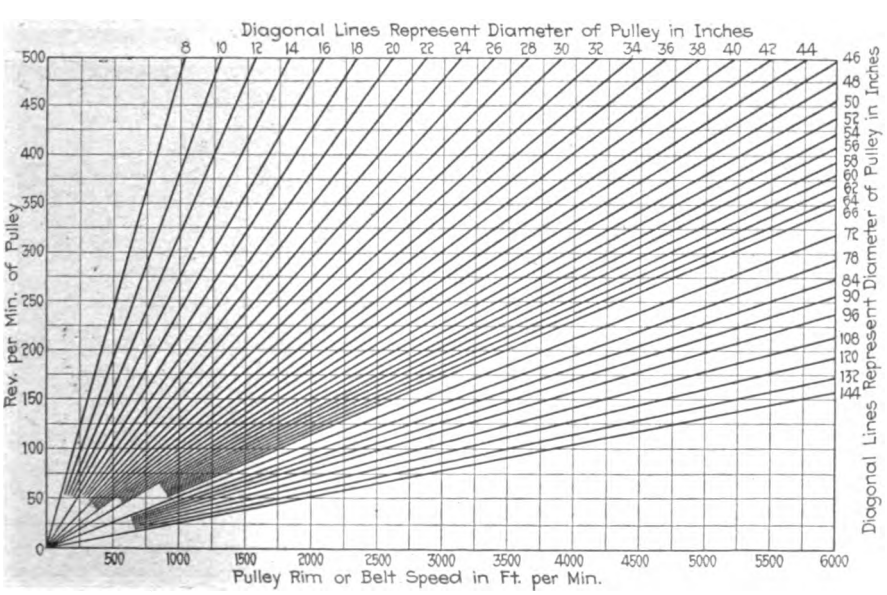
Weight of Belt	Value of Constant
Light Single	660
Heavy Single	575
Light Double	410
Heavy Double	370
Three-ply	330

This implies that the belt is installed and maintained at the proper tension. How to get this tension will be given in the next article of this series.

Unless the belt user knows the grade of canvas of which a fabric or rubber belt is made, the influence of the "friction" binder and other factors, which vary with each grade and make of canvas or rubber belting, it is difficult to use this same rule by applying new constants. However, in such cases the methods recommended by the manufacturers of the belt should be used.

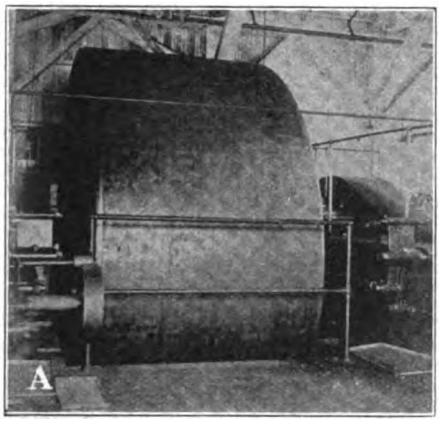
One important consideration in choosing the proper belt is that belts should not be used over pulleys too small in diameter. Instead, if it is desired to use a double belt or heavy belt, the pulley should be made wider, so that a single belt would be able to transmit the same amount of power unless it is possible to increase the diameter of pulleys and consequently the belt speed. Particular attention should be given to this in choosing belts for motors, as ordinarily the motor pulley is of small diameter, due to the necessity of a large reduction in speed between it and the shaft of machine driven. Whenever belts are used over pulleys of too small diameter it results in decreased power, as the belts do not have sufficient arc to grip the pulley tight enough to give it good pulling power. Double belts, if not too stiff, operate very satisfactorily over small pulleys. In many cases it is absolutely necessary to use heavy belts over small pulleys as on side belts on woodworking machinery. The accompanying table gives one set of recommendations as to the smallest diameter pulleys to be used with the various types or grades of leather belting.

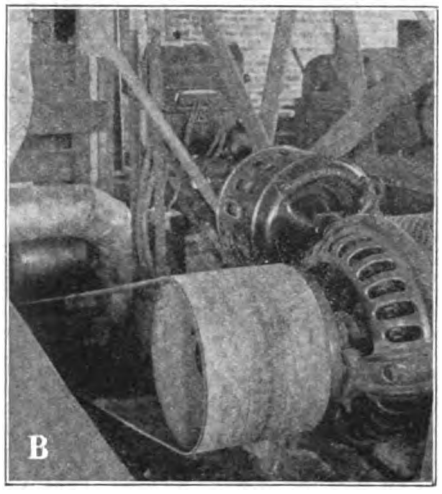
Still greater attention must be paid to this in choosing the proper canvas or rubber belt in relation to the pulley over which it is to operate. Where pulley diameters are ample for the speed at which they revolve, the belt will usually be flexible enough to pass around the pulleys and transmit full power. However, with small, high-speed pulleys care must be taken to limit the number of plies and the construction of the belt so as to prevent ply separation and excessive belt wear. There is no standard set of rules for limiting the number of plies for different diameters of pulleys and speeds, because different manufacturers use various weights of fabric and frictioning compounds to bind the plies together. For this reason the manufacturers' recommendations should always be considered. One manufacturer of rubber belts recommends the relation of pulley diameter, speed and plies as shown in the accompanying table. In this the belts are manufactured in three different weights; light, medium and heavy. These are made from 28-oz., 32-oz., and 36-oz. duck folded into the requisite number of plies. To say that 32-oz. duck is used means that



Charts for determining belt speed when r. p. m. and diameter of pulley are known.
The belt speed in ft. per min. is found at the intersection of the horizontal line representing r. p. m. and the diagonal line representing the diameter of the pulley in inches. Extend downward on the vertical line at the intersection and read the ft. per min. at the bottom.

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Some Applications of

Leather and Fabric Belts

in Industrial Works

A—This 84-in. leather belt on a sawmill drive required the best part of 250 steer hides.

B—A 15-in., 5-ply rubber belt drives a 6-ft., 10-in. bandsaw. It is bad practice to have the belt extend over the end of the pulley as shown here.

C—Operating conditions are such that this 6-in. Balata belt runs continuously in water.

D—This 10-in., 6-ply, stitched, endless, vertical drive belt on a marble gang-saw drive operates 24 hrs. per day. Tension is maintained with a tightener pulley.

E—Two heavy leather belts are operated over the same driving pulley in this steel mill installation.

F—A 5-in. leather belt on a 9-in. cast-iron motor pulley revolving at 700 r.p.m. drives a 42-in. pulley on an air compresser. Here the equipment is operating at half load. The large amount of slack in the belt is due to the method of treatment.

G—Wood-working machinery is a particularly hard drive. Here a 5-in., 4-ply rubber belt drives the top-head matcher at the Pacific Door and Sash Company, Los Angeles, Calif.

H—In many cases endless ropes are used in place of belts, as on this grain elevator.

I—An endless, 12-in., 6-ply Balata belt operates a large stone gang-saw at a 1¼-in. cut per minute.

J—Solid-woven cotton belt on a vertical drive operates rotary hammer, which is a severe service, due to intermittent load.

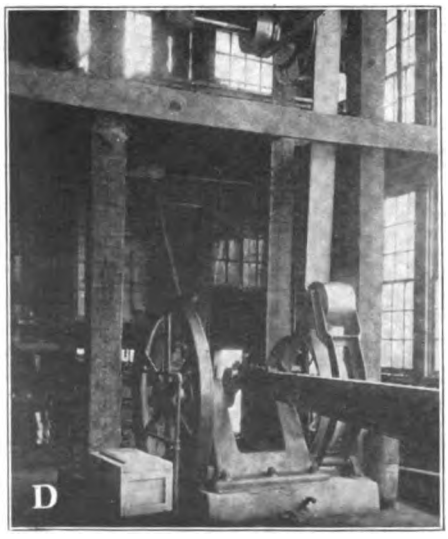
K—This 300 hp. cement mill drive is operated by a 28-in., 7-ply rubber belt at 3,300 ft. per min.

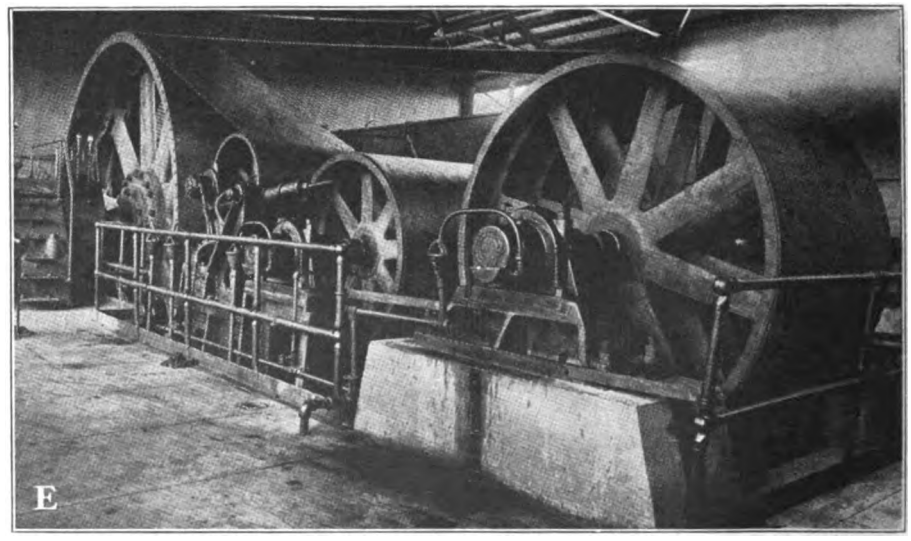
L—This group of twenty marble gang-saws is equipped with 9-in., 5-ply stitched belts. A leather belt is used for the motor drive to lineshaft.

M—In very dusty locations, as in this clay products plant, an allowance of from 5 to 10 per cent must be made, on account of loss due to excessive slippage under these poor operating conditions.

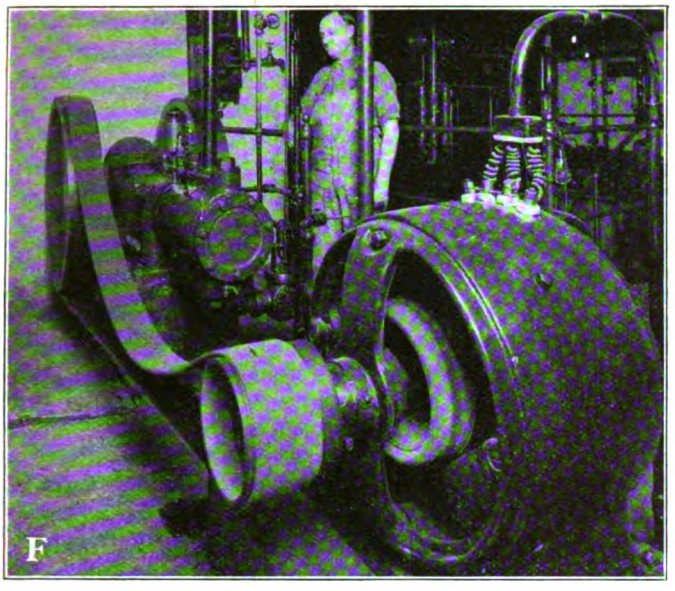
N—Belts, operated with a tightener pulley on such short centers as these, are under a particularly heavy strain, due to the reverse flexing of the fibers.

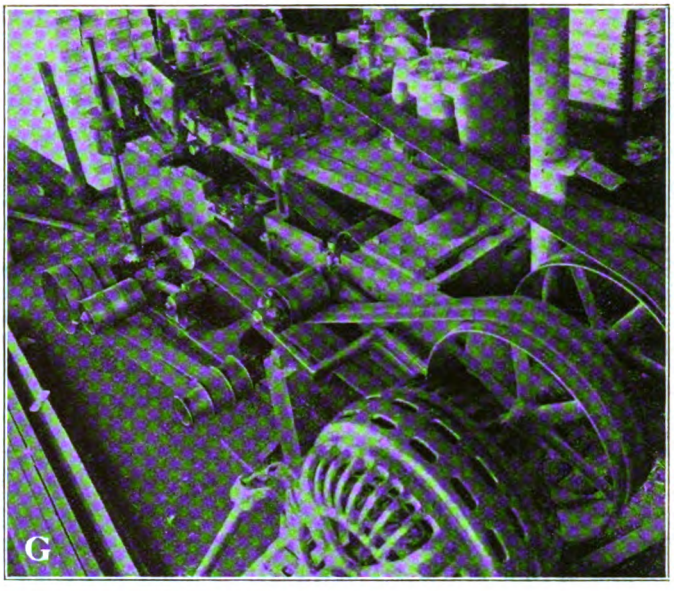
O—Industrial plants are still one of the big users of belts; many of them have literally miles of 2-in. to 5-in. belts.

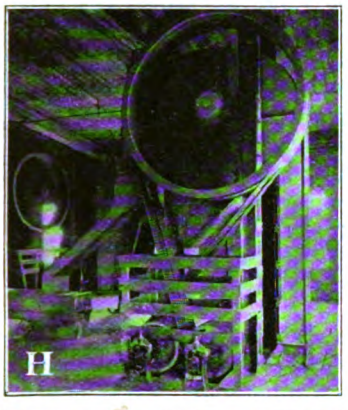


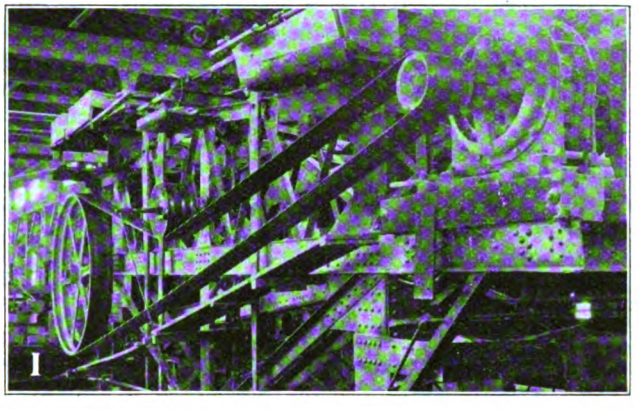


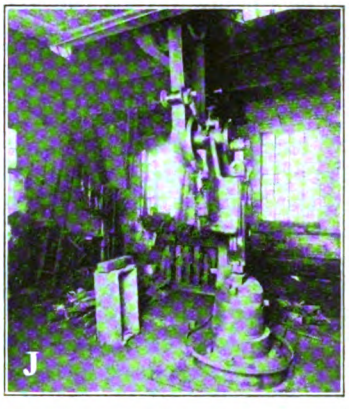
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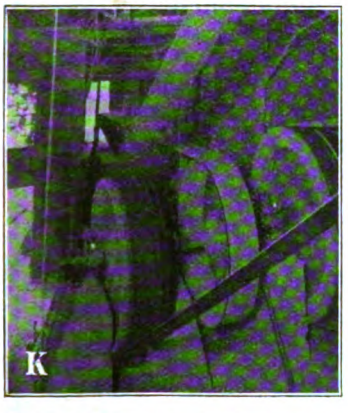

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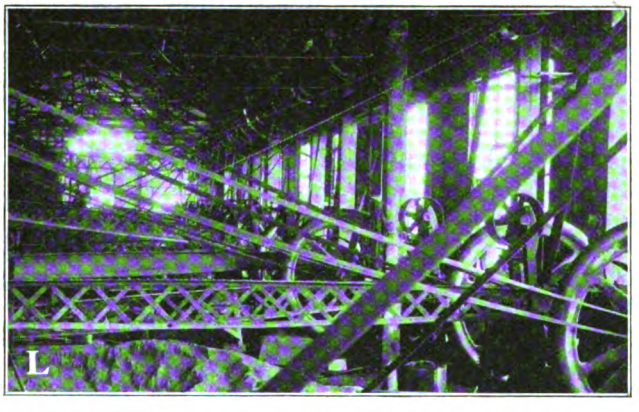

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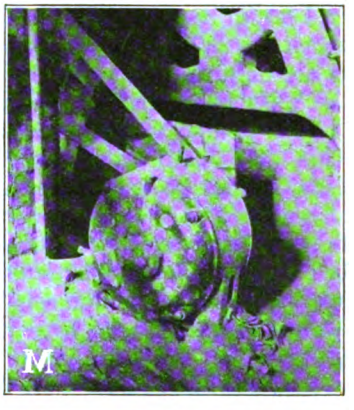

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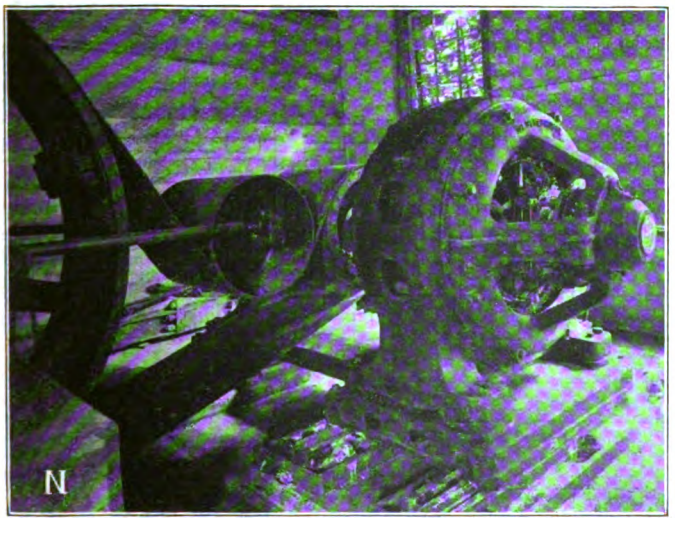

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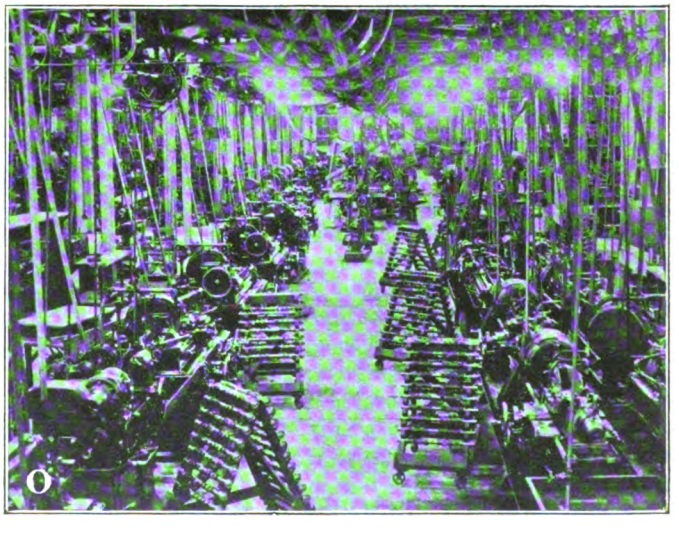

J


K


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M


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Minimum Diameter of Pulleys Over Which Leather Belts May Be Successfully Operated

Width	Ply	Weight	Linear Velocity of Belt in Feet Per Minute		
			1,000	2,000	3,000 and up
Up to 8 in.	Single	Light	2 in.	2½ in.	3 in.
		Medium	3 in.	3½ in.	4 in.
		Heavy	4 in.	5 in.	6 in.
Up to 12 in.	Double	Light	4 in.	5 in.	6 in.
		Medium	8 in.	10 in.	12 in.
		Heavy	10 in.	13 in.	14 in.
Up to 24 in.	Triple	Heavy	24 in.	30 in.	36 in.

a piece of duck measuring 36 in. by 42 in. weighs exactly 32 oz. The weight of the fabric is difficult to determine by the belt user, and so he must rely upon the manufacturer's statement.

In rubber belts the "friction" of the rubber composition which is used to hold the plies together is of importance in determining the value of the belt. In testing a rubber belt it is not sufficient to judge its qualities simply by seeing how much strength is required to tear apart the plies and overcome the "friction" binder. In rubber belting, as in the other types of belting, as was pointed out in the previous article on belts in the March issue, strength is not the only important factor. It is not only the strength which holds the plies together, but also the life of the binder which is important. This, like many other qualities in belts, cannot be determined fully in advance. For that reason it is well to keep records of various types of belt installations, particularly if operating under similar service conditions, and determine by experience the service rendered, the repairs needed and the shutdowns caused by the belts. Records of this sort will aid in determining whether a belt is not fitted for any particular service, and also the most economical types of belts. A later article will illustrate various types of belt records.

In choosing a belt for an equipment allowances must be made for other than ideal operating conditions. Perhaps the nearest to an ideal condition would be where the pulleys are approximately of the same diameter, large enough so that there is not extreme flexing of the belt in passing over the pulley, and where the shafts are in a horizontal plane with the driving side underneath, so that any slack in the return belt will give a slightly additional contact to the pulley.

In vertical drives, especially when the small pulley is placed below and the large one above, the arc of contact is very greatly reduced, and as the belt stretches under load it sometimes falls entirely away from the lower pulley. In many instances the capacity of the belt is decreased 50 per cent in vertical arrangements of this sort.

One of the accompanying illustrations, page 195, shows three arrangements for vertical drive. Of these the third is by far the most effective. In this case, however, the power transmitted decreases whenever the angle shown increases over 40 degrees from the horizontal. One method of estimating the loss due to decreased effectiveness of these drives is to subtract one per cent of the capacity of the belt for every degree over the 40 deg. mark. For example, if a belt drive is at an angle of 65 deg. from the horizontal, the lost capacity would be 65 minus 40, or 25 per cent. Thus any belt used in this case would have its capacity decreased 25 per cent, or in other words, it would require a belt one-third over the rated capacity to drive this installation. For example—a 20 hp. belt would be required where ordinary computations would show that 15 hp. would be sufficient. A vertical belt would give only 50 per cent of its rated capacity, or in other words, the belt would have to be double the capacity shown by ordinary computations. It is often better to add capacity in vertical drives by increasing the width of the belt rather than by using one thicker or heavier.

Minimum Pulley Diameters Recommended for Different Speeds and Weights of Rubber Belts

Operating Conditions		Weight of Belt Recommended*			
Pulley Diameter	Speed Ft. Per Min.	Special Not Over	Light Not Over	Heavy Not Over	Extra Hy. Not Over
4 in.	Over 2000	4 Plies	3 Plies		
	Under 2000	5 Plies	4 Plies		
5 to 6 in.	Over 2000	5 Plies	3 Plies		
	1000—2000	5 Plies	4 Plies		
	Under 1000	6 Plies	5 Plies	4 Plies	
7 to 8 in.	Over 2000	5 Plies	4 Plies		
	1000—2000	6 Plies	4 Plies	4 Plies	
	Under 1000	7 Plies	5 Plies	4 Plies	
9 to 11 in.	1500—2000	7 Plies	5 Plies	4 Plies	
	1000—1500	7 Plies	5 Plies	5 Plies	
	600—1000	8 Plies	6 Plies	5 Plies	4 Plies
	Under 600		6 Plies	6 Plies	4 Plies
12 to 15 in.	1200—1800		5 Plies	4 Plies	4 Plies
	600—1200		6 Plies	5 Plies	5 Plies
	Under 600		6 Plies	6 Plies	5 Plies
16 to 20 in.	900—1200		7 Plies	6 Plies	5 Plies
	600— 900		7 Plies	6 Plies	6 Plies
	Under 600		8 Plies	7 Plies	6 Plies
21 to 30 in.	Any Speed			7 Plies	6 Plies
Over 30 in.	Any Speed			8 Plies	7 Plies
Over 36 in.	Any Speed				8 Plies

*These figures of course are not hard and fast rules but are good standard practice.

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One of the most common allowances which must be made is for an arc of contact of less than 180 deg., due to a difference in diameter of the large and small pulleys. One method of determining this arc of contact is by the following formula:

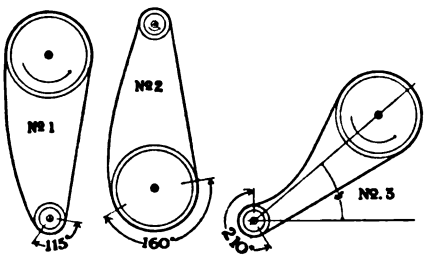
Arc of contact in degrees =
180 — [60×(D-d)÷L]
D=Diameter of large pulley in inches.
d =Diameter of small pulley in inches.
L=the distance between centers of shaft in inches.

This formula will not give the exact arc of contact, but is close enough approximation for ordinary purposes. The accompanying table gives the percentage of the ordinary capacity actually transmitted by a belt because of a lower arc of contact than 180 deg. For example, if the loss is 10 per cent a belt which would ordinarily transmit 55 hp. would transmit only 50 hp.

If the arc of contact on the smaller pulley varies from 180 degrees the amount of power transmitted will be in about the following proportions:

170 deg. 97 per cent	120 deg. 79 per cent
160 deg. 94 per cent	110 deg. 75 per cent
150 deg. 91 per cent	100 deg. 70 per cent
140 deg. 87 per cent	90 deg. 65 per cent
130 deg. 83 per cent	

Where there is an extreme difference between the diameters of the driver and driven pulleys and they are placed on short centers, it is frequently necessary to use an idler. This gives a larger arc of contact on the small pulley, and also maintains the tension. This is hard service on a belt, in that it gives a reverse bending as it passes over the idler pulley. Great care must be exercised to see that a satisfactory pliable belt is used. For cases of this sort a chrome-tanned leather belt is often ordered.



Three types of arrangements for a vertical drive.

Of these, No. 1, at the left, is least effective and calls for extremely high tension or an allowance of about 50 per cent loss in operating efficiency. The second arrangement is much better. This, however, calls for an allowance of from 15 to 25 per cent. The third arrangement is the best. One plan is to allow 1 per cent loss in effectiveness for every degree over 40 deg. from the horizontal. These illustrations are by the courtesy of Chas. A. Schieren Company.

Usually little is gained by operating belts at a greater speed than 4,500 ft. per min., although many are operated satisfactorily up to 5,000. Above this point the centrifugal force of the belt simply lifts the belt from the pulley and so decreases the friction contact which gives a belt its pulling power. To overcome this force it is necessary to increase the tension which often results in short life, friction loss and frequently causes considerable trouble. It usually is possible to reduce the speed of the belt by decreasing the diameter of the pulley, and thereby eliminate the cause of the trouble. It must be remembered, however, that if the speed is decreased a larger belt, preferably wider, must be used to transmit the same horsepower.

In ordering a belt for any special location, certain information should be given. All the questions which have any bearing on the selection of a belt for unusual service are shown in the card reproduced with this article. In ordering a leather belt the following information must be given:

1. LENGTH. State exactly the distance around the pulley. Do not give length including lap for the manufacturer will allow the proper additional length for the lap.

2. ENDS. State whether belt is to be shipped "endless," or "square ends," or "and lap," or what means the same as the last, "lap extra."

3. WIDTH. State the exact width.

4. GRADE. Specify the grade of belt desired or suggest that the manufacturer supply what he recommends for the conditions specified. If conditions are unusual give complete information similar to that listed on the accompanying card.

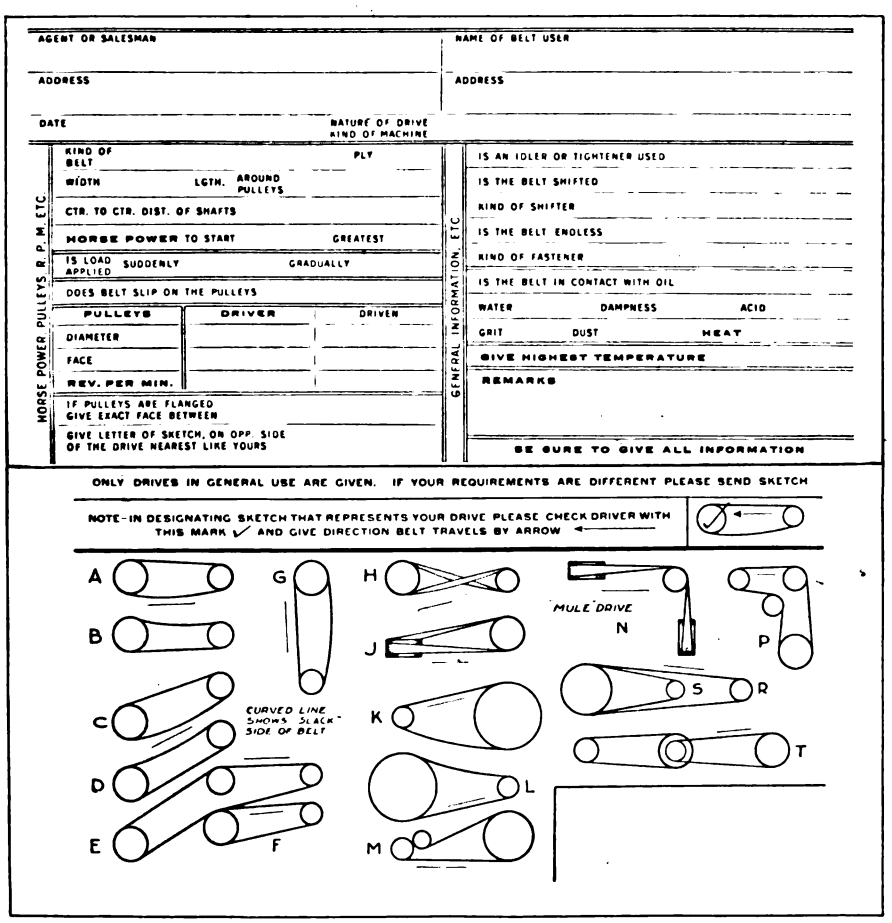
5. PLY. State whether single, double or three-ply.

6. LAP. State if other than cemented lap is required.

7. FINISH. State whether oil dressed or regular finish is wanted.

Wherever possible it is best that belts be made endless. Methods of doing this will be shown in the next article in this series, which will appear in a later issue. If the belt is to be prepared endless by the manufacturer, it is necessary that he have accurate measurements. When measuring around pulleys to get the length of a belt use a steel tape or a wire, as other devices will stretch.

Formulas which may be used to


AGENT OR SALESMAN
NAME OF BELT USER
ADDRESS
ADDRESS
DATE
NATURE OF DRIVE
KIND OF MACHINE
HORSE POWER, PULLEYS, R.P.M. ETC.
KIND OF BELT
PLY
WIDTH
LGTH. AROUND PULLEYS
CTR. TO CTR. DIST. OF SHAFTS
HORSE POWER TO START
GREATEST
IS LOAD APPLIED SUDDENLY
GRADUALLY
DOES BELT SLIP ON THE PULLEYS
PULLEYS
DRIVER
DRIVEN
DIAMETER
FACE
REV. PER MIN.
IF PULLEYS ARE FLANGED GIVE EXACT FACE BETWEEN
GIVE LETTER OF SKETCH, ON OPP. SIDE OF THE DRIVE NEAREST LIKE YOURS
GENERAL INFORMATION, ETC.
IS AN IDLER OR TIGHTENER USED
IS THE BELT SHIFTED
KIND OF SHIFTER
IS THE BELT ENDLESS
KIND OF FASTENER
IS THE BELT IN CONTACT WITH OIL
WATER
DAMPNESS
ACID
GRIT
DUST
HEAT
GIVE HIGHEST TEMPERATURE
REMARKS
BE SURE TO GIVE ALL INFORMATION
ONLY DRIVES IN GENERAL USE ARE GIVEN. IF YOUR REQUIREMENTS ARE DIFFERENT PLEASE SEND SKETCH
NOTE—IN DESIGNATING SKETCH THAT REPRESENTS YOUR DRIVE PLEASE CHECK DRIVER WITH THIS MARK ✓ AND GIVE DIRECTION BELT TRAVELS BY ARROW
A
B
C
D
E
F
G
CURVED LINE SHOWS SLACK SIDE OF BELT
H
J
K
L
M
MULE DRIVE
N
P
R
S
T

The front and back of this card is used to gather belt installation information.

This card is used by the Victor Balata and Textile Belting Company to gather information on an industrial installation which calls for unusual belt service. With the information given here, the engineering department of any belting company can make recommendations as to the best type and size of belt for any particular service.

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determine the length of belts when pulleys are of different sizes or the same size, or for cross belts, are shown in the accompanying box. If a belt is to be ordered for a quarter turn, mule stand or for other unusual conditions, it is best to send a blue print with dimensions, in addition to the service conditions, to the belt manufacturer, and ask for his recommendations.

Having determined upon a belt which at the given belt speed will deliver the correct power, and of flexibility suited to pulley diameters and speeds, we must look for individual conditions that will affect the life of the belt. Some of these, in addition to those already mentioned, are as follows:

An idler pulley so placed that it flexes the belt to any extent calls for more flexibility than an open installation.

If shifters are used the belt must have sufficient lateral stiffness. For general use, a wide, thin belt is preferable; here a narrower and thicker belt will work better. This is particularly true on cone pulleys and to some extent where belts are crossed, but with crossed belts flexibility is necessary if pulley centers are at all short.

Quarter-turn drives, mule stands and such installations must have a proper balance of flexibility and lateral strength.

The presence of excessive dust or dirt will probably cause slippage and require slight over-belting. In such cases it is preferable to increase the width.

Excessive oil is injurious to rubber or fabric belting, and decreases the value of leather belt.

The presence of water, steam, moisture or conditions of high humidity work against the best results from leather or fabric belts, unless specially treated to withstand the conditions.

Hot, dry conditions are unfavorable for any belts.

When work requires that the belt slip, it will burn out; this is particularly true of rubber or fabric, with link leather probably the least affected.

Belts act as a safety valve in protecting motors and machinery; in cases where motors are not electrically protected or costly machine parts will be broken by overloads, it is expensive to over-belt.

In fitting the belt to the particular service condition under which it is operating, it should always be remembered that the farther the operating conditions are from ideal belting conditions, the greater will be the allowance necessary for overcoming these conditions. A number of these allowances have been indicated in this article. Frequently these conditions can be overcome. Some of the ways of doing this will be taken up in the next article on servicing belts.

Allowance to Be Made for Belts Operating Under Abnormal Conditions

Belts will be unable to deliver their full capacity and their output will be conditioned by the percentage indicated. This should be made up by wider, thicker, stronger belts, or by operating at a greater belt speed as required.

1. **Where there is a very large difference between the pulley diameters, especially if operated on short centers, add 10 to 15 per cent.**
2. **When operated at excessively high belt speed, from 4,250 to 5,000 ft. per min., add 5 to 10 per cent. From 5,250 to 6,000 ft. per min., add 12½ to 20 per cent.**
3. **Quarter and half turns, add 25 to 50 per cent.**
4. **On horizontal drives with the pulling end of the belt on top, add about 7½ per cent.**
5. **On intermittent drives, such as rolling mills, add about 25 per cent. Crushers or compressors, add about 20 per cent.**

The author wishes to acknowledge special assistance from J. R. Hopkins, Chicago Belting Co., R. E. Moore, Chas. A. Schieren Co., and R. H. Whitney, The B. F. Goodrich Rubber Co., in the preparation of this and other articles in this series.

EDITOR'S NOTE: Acknowledgement is made to the following companies for assisting in furnishing information and photographs for this and the other articles which will follow in this series: Louis W. Arny, Sec., The Leather Belting Exchange, 119 S. Fourth St., Philadelphia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; The Bristol Co., Waterbury, Conn.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Belt Lacer Co., Detroit, Mich.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co.; Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Goodyear Tire & Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Indianapolis, Ind.; Imperial Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; New York Rubber Co., New York, N. Y.; W. H. Salisbury & Co., Chicago, Ill.; Chas. A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Machinery & Supply Co., New York, N. Y.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

National Electrical Code Changes

(Continued from page 187.)

Permission is required to assure that the system to which the branch circuit is attached is properly grounded and that an identified grounded conductor is carried throughout the installation.

The omission of the fuse in the grounded side of branch circuits, it is considered by the committee, should be a part of a more general method of wiring which includes also the grounding of secondary circuits in a thoroughly reliable and permanent manner and use in installations of an identified grounded wire throughout the building properly connected to all fittings. Proper grounding of circuits and the polarization of wiring is not universal by any means yet, and it is felt that the omission of the fuse in the neutral should, therefore, be allowed at present only in places where the inspection department has determined that the grounding and polarization is provided. It is expected that such permission will be given by inspection departments for systems, cities and parts of cities where this program is known to have been actually carried out, rather than by a separate ruling on new buildings in every case.

FUSES FOR 125-VOLT BRANCH CIRCUITS

Instead of placing a maximum limit of 10 amp. on 125-volt branch-circuit fuses, the Code now allows 15 amp. for ordinary branch circuits and 40 amp. for circuits designed for "Mogul" sockets. The old limitation of 660 watts per branch circuit has been abolished. Twelve outlets are allowed on two-wire branch circuits and on each side of three-wire circuits. Likewise eight "Mogul" sockets may be connected per branch circuit if fused for 40 amp. on 125 volts.

Where two motors on a crane operate and *(Continued on page 225.)*

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Rules and Examples Showing

How to Group Coils

In Windings of Induction Motors Having Any Number of Coils in Equal and Unequal Groups

UNEQUAL GROUPING of the coils in induction motors may look like higher mathematics to those who have not had it explained to them, but it is not as difficult as it appears. In this article Mr. Roe gives some rules for both equal and unequal grouping. These rules are made up so that they will be easy to follow. They give just the information that is needed to handle a winding job that may not be covered in the tables which are being published with this series of articles which started in the March issue of INDUSTRIAL ENGINEER.

By A. C. ROE

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IT is not difficult to determine the proper grouping of coils for any induction motor when the details of the method to use are understood. These details and some of the ways of figuring out groupings are explained in the following paragraphs. Of course the majority of windings are covered by the *Main Table* and the *Winding Diagrams* which appeared in the March issue on page 138 that accompany this series of articles. But for those cases that are not covered in the diagrams, these general instructions will be useful.

Any winding will fall in one of the four methods of grouping: (1) Equal grouping; (2) equal grouping with some dead coils; (3) unequal grouping; (4) unequal grouping with some dead coils.

There is also a fifth possibility, which is, that the particular winding is not practicable with the given number of coils. The rules and examples beginning on page 205, will show in which of these classes any winding belongs and will explain how to make the various arrangements of coils in groups.

ARRANGING UNEQUAL GROUPS

A correct arrangement of unequal groups of coils can be worked out in several ways. One method is by following an arrangement similar to that shown in the accompanying

Four-Pole and Eight-Pole Unequal Grouping*

In the last issue the two tables below contained errors which should be corrected. The entire tables are printed below in the correct form.

UNEQUAL COIL GROUPING

FOUR-POLE THREE-PHASE, CHART D

Top-to-Top

Coils	Group Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	1	2	1	2	1	2	1	2	1	2	1
54	4	5	4	5	4	5	4	5	4	5	4	5
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7–1	7	6	7	7–1	7	6	7	6	7
86	7	7	8–1	7	7	7	8–1	7	7	7	7	7
90	7	8	7	8	7	8	7	8	7	8	7	8
104	8	9	9–1	9	8	9	9–1	9	8	9	8	9
128	10	11	11–1	11	10	11	11–1	11	10	11	10	11
135	12–1	11	11	11	12–1	11	11	11	12–1	11	11	11
150	12	13	12	13	12	13	12	13	12	13	12	13
160	14–1	13	13	13	14–1	13	13	13	14–1	13	13	14–1

Top-to-Bottom

Coils	Group Numbers											
	1	2	3	4	5	6	7	8	9	10	11	12
18	2	1	2	1	2	1	1	2	1	2	1	2
54	4	5	4	5	4	5	5	4	5	4	5	4
62	6–1	5	5	5	5	5	5	6–1	5	5	5	5
80	6	7	7–1	7	6	7	7	7–1	7	6	7	6
86	7	7	8–1	7	7	7	8–1	7	7	7	7	7
90	7	8	7	8	7	8	8	7	8	7	8	7
104	8	9	9–1	9	8	9	9	9–1	9	8	9	8
128	10	11	11–1	11	10	11	11	11–1	11	10	11	10
135	12–1	11	11	11	12–1	11	11	11	12–1	11	11	11
150	12	13	12	13	12	13	13	12	13	12	13	12
160	14–1	13	13	13	14–1	13	13	13	14–1	13	13	14–1

EIGHT-POLE THREE-PHASE, CHART H

Top-to-Bottom

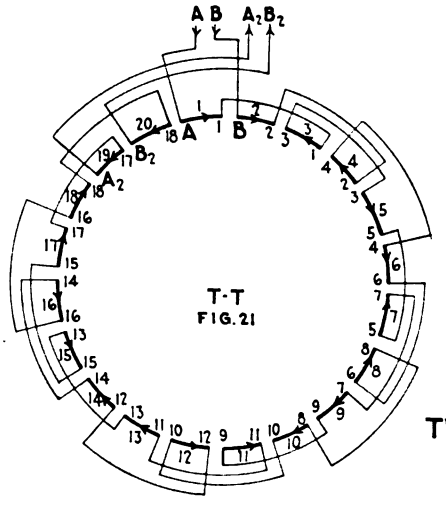
Coils	Group Numbers																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	1	2	1	2	1	1	2	1	2	1	2	2	1	2	1	2	1	1	2	1	2	1	2
54	3	2	2	2	2	2	2	3	2	2	2	3	2	2	3	2	3	2	2	2	2	3	2	2
60	3	2	3	2	3	2	2	3	2	3	2	3	3	2	3	2	3	2	2	3	2	3	2	3
62	3	3–1	3	2	3	2	2	3	2	3	2	3	3	3–1	3	2	3	2	2	3	2	3	2	3
80	4	3	3	3	4–1	3	3	4	3	3	3	4	3	3	4	3	4	3	3	4–1	3	4	3	3
84	4	3	4	3	4	3	3	4	3	4	3	4	4	3	4	3	4	3	3	4	3	4	3	4
86	4	4–1	4	3	4	3	3	4	3	4	3	4	4	4–1	4	3	4	3	3	4	3	4	3	4
90	3	4	4	4	4[k]	3	4	3	3	4[k]	4	4	4[k]	4[k]	4	4	3	4[k]	4	4	4[k]	3	4	4
104	5[k]	4	4	4	5–1	4	4	5[k]	4	4	4	5[k]	4	4	5[k]	4	5[k]	4	4	5–1	4	5[k]	4	4
108	5	4	5	4	5	4	4	5	4	5	4	5	5	4	5	4	5	4	4	5	4	5	4	5
128	6[k]	5	5	5	6–1	5	5	6[k]	5	5	5	6[k]	5	5	6[k]	5	6[k]	5	5	6–1	5	6[k]	5	5
135	6	5	6	6–1	6	5	5	6	5	6	6–1	6	6	5	6	5	6	6–1	5	6	5	6	5	6
150	7[k]	6	6	6	6	6	6	7[k]	6	6	6	7[k]	6	6	7[k]	6	7[k]	6	6	6	6	7[k]	6	6
156	7	6	7	6	7	6	6	7	6	7	6	7	7	6	7	6	7	6	6	7	6	7	6	7
160	7	7–1	7	6	7	7–1	6	7	6	7	6	7	7	7–1	7	6	7	7–1	6	7	6	7	6	7
180	8	7	8	7	8	7	7	8	7	8	7	8	8	7	8	7	8	7	7	8	7	8	7	8

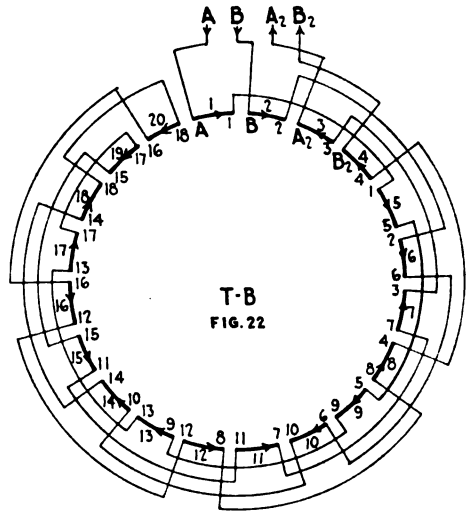
[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

* It is suggested that the former tables referring to these groupings be marked with a reference to these corrected tables.

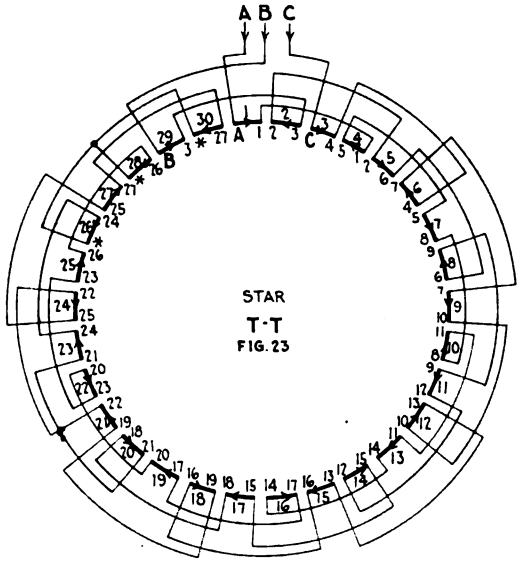
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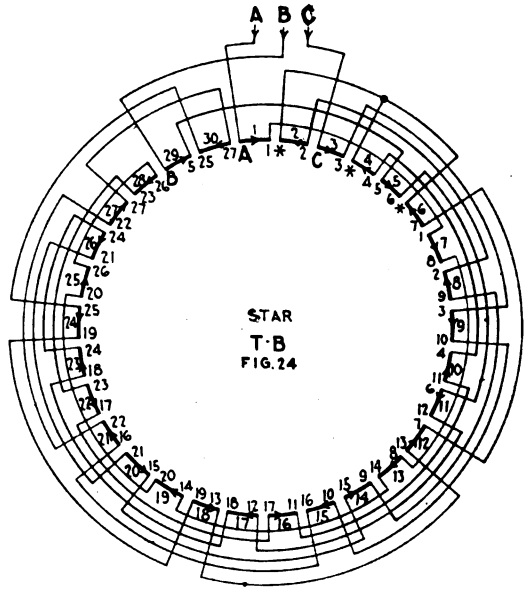
Ten-Pole Windings

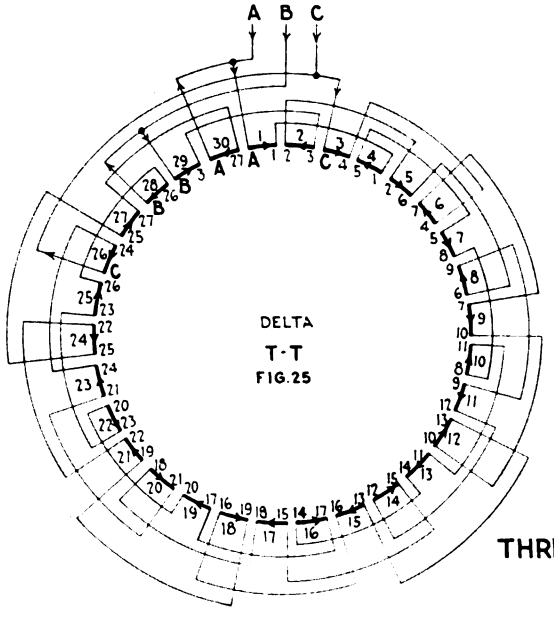


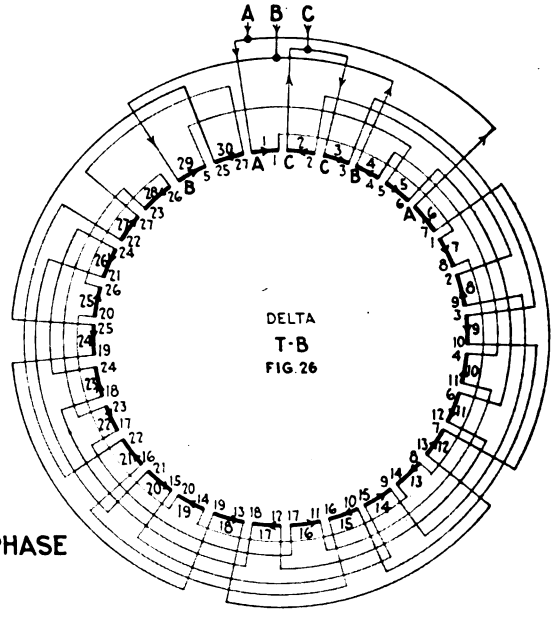


TWO-PHASE









THREE-PHASE

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CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same numbers or letters. Line leads are indicated by letters. A star connection is shown by (*).

Two-Phase, Top-to-Top. See Fig. 21

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	A_2 17	B_2 18
2 Parallel	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 A_2	8 B_2	11 A	12 B	11 13	12 14	15 13	16 14	15 17	16 18	A_2 17	B_2 18
5 Parallel	A 1	B 2	A_2 1	B_2 2	A 5	B 6	A_2 5	B_2 6	A 9	B 10	A_2 9	B_2 10	A 13	B 14	A_2 13	B_2 14	A 17	B 18	A_2 17	B_2 18
10 Parallel	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B

Two-Phase, Top-to-Bottom. See Fig. 22

Series	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 7	4 8	5 9	6 10	7 11	8 12	9 13	10 14	11 15	12 16	13 17	14 18	15 17	16 18
2 Parallel	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 7	4 8	5 9	6 10	7 11	8 12	9 13	10 14	11 15	12 16	13 A_2	14 B_2	15 A	16 B
5 Parallel	A 1	B 2	A_2 3	B_2 4	1 A_2	2 B_2	3 A	4 B	A 9	B 10	A_2 11	B_2 12	9 A_2	10 B_2	11 A	12 B	A 17	B 18	A_2 17	B_2 18
10 Parallel	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B

Three-Phase Star, Top-to-Top. See Fig. 23

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	* 24	25 27	* 26	B 3	* 27
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 *	13 10	11 *	15 B	13 *	18 A	15 18	19 C	17 20	21 18	19 22	23 20	21 24	25 22	23 26	* 24	25 27	* 26	B 3	* 27
5 Parallel	A 1	* 3	C 4	* 1	B 6	* 4	A 8	* 6	C 10	* 8	B 12	* 10	A 14	* 12	C 16	* 14	B 18	* 16	A 20	* 18	C 22	* 20	B 24	* 22	A 26	* 24	C 27	* 26	B 3	* 27
10 Parallel	A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C

Three-Phase Star, Top-to-Bottom. See Fig. 24

Series	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 24	22 27	23 26	B 5	25 27
2 Parallel	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19	14 20	15 21	16 22	17 23	18 *	19 25	20 *	21 B	22 *	23 A	B 5	25 C
5 Series	A 1	* 2	C 3	* 4	5 *	* 7	1 *	2 B	3 *	4 A	B 12	7 C	A 14	* 15	C 16	* 17	12 *	* 19	14 *	15 B	16 *	17 A	B 24	19 C	A 26	* 24	C 27	* 26	B 5	* 27
10 Parallel	A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C A	* *	B C	* *	A B	* *	C

Three-Phase Delta, Top-to-Top. See Fig. 25

Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	C 24	25 27	B 26	B 3	A 27
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 C	13 10	11 B	15 B	13 A	17 A	15 18	19 C	17 20	21 18	19 22	23 20	21 24	25 22	23 26	C 24	25 27	B 26	B 3	A 27
5 Parallel	A 1	C 3	C 4	B 1	B 6	A 4	A 8	C 6	C 10	B 8	B 12	A 10	A 14	C 12	C 16	B 14	B 18	A 16	A 20	C 18	C 22	B 20	B 24	A 22	A 26	C 24	C 27	B 26	B 3	A 27
10 Parallel	A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C

Three-Phase Delta, Top-to-Bottom. See Fig. 26

Series	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 24	22 27	23 26	B 5	25 27
2 Parallel	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19	14 20	15 21	16 22	17 23	18 C	19 25	20 B	21 B	22 A	23 A	B 5	25 C
5 Parallel	A 1	C 2	C 3	B 4	5 C	A 7	1 B	2 B	3 A	4 A	B 12	7 C	A 14	C 15	C 16	B 17	12 C	A 19	14 B	15 B	16 A	17 A	B 24	19 C	A 26	C 24	C 27	B 26	B 5	A 27
10 Parallel	A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C A	B C	B C	A B	A B	C A	C

For Ten-Pole Windings

When using these tables refer to the diagrams that are marked Fig. 21, Fig. 22, Fig. 23, Fig. 24, Fig. 25 and Fig. 26.

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winding diagrams. Table 1 (page 205 will help in this method. Another method is to lay out the groups on paper and thus determine the best arrangement. A third plan makes use of the inner circles on the diagrams as shown in the winding diagrams for fourteen poles and over. All of these methods are explained in the following paragraphs.

For the first method, suppose as an example, we have the twelve-pole, three-phase winding with 90 coils, mentioned in the Example for Rule II-(*a*). There are 36 groups in this winding (12 poles $\times$ 3 phases=36). Now, as before, dividing the 90 coils by 36, we have 90÷36=2 and a remainder of 18. This means that 18 groups will have an extra coil apiece, or 2+1=3 coils. The other groups, 36—18=18, will have 2 coils apiece. Therefore there are eighteen large groups and eighteen small groups. Now in Table I (page 205) consult the section for twelve poles and three phases. (For windings having more than fourteen poles, the information is included in the winding diagrams for unequal grouping and not in Table I.) We see in the fifth column of Table I opposite 18 and 18, the figure 54. The 54-coil winding also has 18 large groups and 18 small groups and should be used as a guide. It will be found in Chart N.

The second method may be followed where no guide can be found in Table I on page 205. In this method the groups are set down on paper, as shown in Table II on page 205. Cross-section paper is the best to use. The particular winding shown in Table II has twenty-four coils and it is desired to connect them for six poles, three-phase series.

There are eighteen groups in this winding (6$\times$3=18). Numbers corresponding to these groups are put down in the first line. Underneath, in line 2, are placed letters *A*, *B* and *C* to show the phase of the groups. Now there are twenty-four coils and eighteen groups, and dividing 24 by 18 we get a quotient of 1 and a remainder of 6. Therefore there are six large groups with two coils each and twelve small groups with 1 coil each. Now with eighteen groups total and six large groups, we get a pitch of 1 and 4 for the large groups (18÷6=3, which gives a pitch of 1 and 4. In line 3 of Table II (page 205) the cross marks ($\times$) show the location of the large groups spaced 1 and 4. In this case it happens that all the groups would fall in the *A* phase if placed in this way. They must however be distributed equally among the three phases. To do this we can let the first one remain in the *A* phase as shown in line 5 of Table II. The next large group must be placed in another phase. Usually it is better to place the second one in the *C* phase. This is done in line 5. It is placed in the *C* phase of the same pole in which it was placed in line 3. The next large group is now

Ten-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, CHART K

Top-to-Top Connections

No. Coils	Group Numbers																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
48	3	2	2	3	3	2	2	3	2	2	3	2	2	3	3	2	2	3	2	2
54	2	3	3	2	3	3	2	3[k]	3	3	2	3	3	2	3[k]	3	2	3	3	3
62	4–1	3	3	3	3	3	3	3	3	3	3	4–1	3	3	3	3	3	3	3	3
72	3	4	4	3	3	4	4	3	4	4	3	4[k]	4	3	3	4	4	3	4[k]	4
84	5[k]	4	4	4	4	5[k]	4	4	4	4	5[k]	4	4	4	4	5[k]	4	4	4	4
86	5[k]	4	4	5–1	4	5[k]	4	4	4	4	5[k]	4	5–1	4	4	5[k]	4	4	4	4
90	5–1	4	4	4	5	5	4	4	5	5	4	5–1	4	4	5	5	4	4	5	5
96	4	5	5	5[k]	5[k]	4	5	5	5	5	4	5[k]	5[k]	5	5	4	5[k]	5	5	5[k]
104	6[k]	5	5	5	5	6[k]	5	5	5	5	6[k]	5	5	5	5	6[k]	5	5	5	5
108	6	5	5	6	6	5	5	6	5	5	6	5	5	6	6	5	5	6	5	5
128	7	6	6	7	7	6	6	7	6	6	7	6	6	7	7	6	6	7	6	6
135	7–1	7	7	6	6	7	7	6	7	7[k]	7–1	7	7	7–1	6	7	7	6	7[k]	7
144	8[k]	7	7	7	7	8[k]	7	7	7	7	8[k]	7	7	7	7	8[k]	7	7	7	7
150	8–1	7	7	7	8	8	7	7	8	8	7	7	7	7	8	8	7	8–1	8	8
156	7	8	8	8	8	7	8	8	8	8	7	8	8	8	8	7	8	8	8	8
168	9	8	8	9	9	8	8	9	8	8	9	8	8	9	9	8	8	9	8	8
216	10	11	11	11	11	10	11	11	11	11	10	11	11	11	11	10	11	11	11	11

[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

THREE-PHASE, CHART L

Top-to-Top and Top-to-Bottom

No. Coils	Group Numbers																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
48	2	1	2	1	2	2	2	1	1	2	2	1	1	2	2	2	1	2	1	2	2	2	1	1	2	2	1	1	2	2
54	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2
62	3-1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3-1	2	2	2	2	2	2	2	2	2	2	2	2
72	2	3	2	3	2	2	2	3	3	2	2	3	3	2	2	3	2	3	2	2	3	2	2	3	2	2	3	3	2	2
80	3	2	3	2	3	3	3	3-1	2	3	3	2	2	3	3	2	3	3	2	3	3	3	2	3-1	3	3	2	2	3	3
84	2	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	2	3	3	3	3	2	3	3	3	3	3	3
86	3-1	3	3	3	3	2	3	3	3	3	2	3	3	3	3	2	3	3	2	3	3	3	3	3-1	3	3	3	3	2	3
96	4	3	3	3	3	4	3	3	3	3	4	3	3	3	3	4	3	3	3	4	3	3	3	4	3	4	3	3	3	3
104	4-1	4	3	4	3	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4-1	4	3	3	3	4	4	4	3	3
108	4	3	4	3	4	4	4	3	3	4	4	3	3	4	4	3	4	4	3	4	4	4	3	3	4	4	3	3	4	4
128	5	4	4	4	5-1	4	4	5	4	4	4	5	4	4	4	5	4	4	4	5-1	4	4	5	4	4	4	5	4	4	4
†135	5	4	5	4	5	4	5	4	5	4	5	4	5[k]	4	5[k]	4	5	4	5	4	5	4	5	4	5	4	5	4	5[k]	4
144	4	5	5	5	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	5	5	5	4	5	5	5	4	5	5	5
156	6	5	5	5	5	5	5	6	5	5	5	6	5	5	5	6	5	5	5	5	5	5	6	5	5	5	6	5	5	5
160	6	5	5	6-1	5	5	5	6	5	5	6	5	5	6-1	5	6	5	5	5	5	6-1	5	6	5	5	5	6	5	5	6-1
168	6	5	6[k]	5	5	6	5	6	6	6	6	5	6	6[k]	5	6[k]	5	6	5	6	6	6	6	5	6	5	5	5	6	6
216	8[k]	7	7	7	7	7	7	8[k]	7	7	7	8[k]	7	7	7	8[k]	7	7	7	7	7	7	8[k]	7	7	7	8[k]	7	7	7

[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

†Not good for top-to-bottom connection.

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placed in the *B* phase. This is repeated until the end of the winding is reached. The grouping is then as shown in the bottom line.

This grouping holds for a top-to-top winding but it will not always hold for top-to-bottom connections. For top-to-bottom connections we divide the top-to-top winding into poles, numbering them from first to last: 1, 2, 3, 4, 5, 6, etc. Then we move these poles into the following order: 1, last; 2, next-to-last; 3, second-from-last; 4, third-from-last, and so on.

In this way for a six-pole winding the top-to-bottom connection will have the original poles arranged in the following order: 1, 6, 2, 5, 3, 4. Therefore the top-to-bottom grouping for the winding shown in Table II is: 211, 121, 112, 112, 121, 211.

These figures must always be checked to see *that every circuit has the same number of coils and that every phase has the same number.* There may be some cases in which this method will not give a correct connection. It must be remembered in using the three-phase connection diagrams and tables accompanying these articles, that the start of the *B* phase is in the last pole. This phase then passes to the first pole for top-to-top connections. For top-to-bottom connections it passes to the second pole. The *A* and *C* phases start in the first pole.

The third method of locating the large groups uses the inner circles shown in the diagrams for fourteen to twenty-four poles. Similar circles might be drawn in any of the other diagrams. As an example of the method of using these circles, suppose we have a fourteen-pole three-phase winding having forty-eight coils. To find the number of large groups divide the number of coils by the number of groups. Dividing 48 by 42 we get 1 and a remainder of 6. Then we have six large groups of two coils each. To locate these properly we draw an inner circle as shown in Fig. 34. Then for convenience divide this into parts as shown 10 deg. apart starting with 0 in the center of group No. 1. Now we have six large groups and there are 360 deg. in the circle. Therefore the large groups should be 60 deg. apart (360÷6=60). Therefore they will be located at 0, 60, 120, 180, 240 and 300 deg. These points correspond with groups 1, 8, 15, 22, 29 and 36. These groups are respectively in the following phases: *A*, *B*, *C*, *A*, *B*, *C*. Two of them are in each phase, and these can be made the large groups.

If the points had all fallen in the same phase it would have been necessary to shift some of them so that the large groups would be in the order of phases *A*, *C* and *B* or phases *A*, *B* and *C*.

Twelve-Pole, Two-Phase Windings

UNEQUAL COIL GROUPING—CHART M

Top-to-Top Connections

No. Coils	Group Numbers																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
36	2	2	1	1	2[k]	2[k]	1	1	2	2	1	1	2	2	1	1	2[k]	2[k]	1	1	2	2	1	1
54	3	2	2	2	2	3	2	2	3[k]	2	2	2	2	3	2	2	3	2	2	2	2	3[k]	2	2
60	3[k]	3[k]	2	2	3	3	2	2	3	3	2	2	3[k]	3[k]	2	2	3	3	2	2	3	3	2	2
62	3[k]	3[k]	2	2	3	3	3–1	2	3	3	2	2	3[k]	3[k]	2	2	3	3	2	3–1	3	3	2	2
80	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3
84	4[k]	4[k]	3	3	4	4	3	3	4	4	3	3	4[k]	4[k]	3	3	4	4	3	3	4	4	3	3
86	4[k]	4[k]	3	3	4	4	4–1	3	4	4	3	3	4[k]	4[k]	3	3	4	4	3	4–1	4	4	3	3
90	3	4	4	4	4	3	4	4[k]	3	4	4	4	4	3	4	4	3	4	4[k]	4	4	3	4	4
104	5	4	4	5	4	4	5[k]	4	4	5	4	4	5	4	4	5[k]	4	4	5	4	4	5	4	4
108	5[k]	5[k]	4	4	5	5	4	4	5	5	4	4	5[k]	5[k]	4	4	5	5	4	4	5	5	4	4
128	6	5	5	6	5	5	6[k]	5	5	6	5	5	6	5	5	6[k]	5	5	6	5	5	6	5	5
135	6[k]	6[k]	5	6–1	6	6	5	5	6	6	6–1	5	6[k]	6[k]	5	5	6	6	5	6–1	6	6	5	5
§150	7[k]	6	6	6	6	7	6	6	7	6	6	6	6	7[k]	6	6	7	6	6	6	6	7	6	6
156	7[k]	7[k]	6	6	7	7	6	6	7	7	6	6	7[k]	7[k]	6	6	7	7	6	6	7	7	6	6
160	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7
180	8[k]	8[k]	7	7	8	8	7	7	8	8	7	7	8[k]	8[k]	7	7	8	8	7	7	8	8	7	7

[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

§All connections can be had by killing one coil in each group of seven coils.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Top-to-Top. See Fig. 27

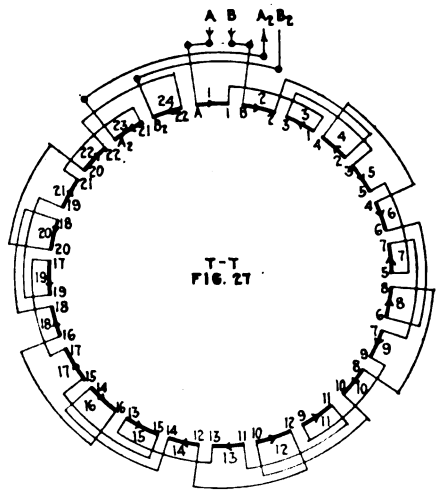
Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18	19 21	20 22	A_2 21	B_2 22
2 Parallel	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	A_2 9	B_2 10	A 13	B 14	15 13	16 14	15 17	16 18	19 17	20 18	19 21	20 22	A_2 21	B_2 22
3 Parallel	A 1	B 2	3 1	4 2	3 5	4 6	A_2 5	B_2 6	A 9	B 10	11 9	12 10	11 13	12 14	A_2 13	B_2 14	A 17	B 18	19 17	20 18	19 21	20 22	A_2 21	B_2 22
4 Parallel	A 1	B 2	3 1	4 2	3 A_2	4 B_2	7 A	8 B	7 9	8 10	A_2 9	B_2 10	A 13	B 14	15 13	16 14	15 A_2	16 B_2	19 A	20 B	19 21	20 22	A_2 21	B_2 22
6 Parallel	A 1	B 2	A_2 1	B_2 2	A 5	B 6	A_2 5	B_2 6	A 9	B 10	A_2 9	B_2 10	A 13	B 14	A_2 13	B_2 14	A 17	B 18	A_2 17	B_2 18	A 21	B 22	A_2 21	B_2 22
2 Parallel	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B

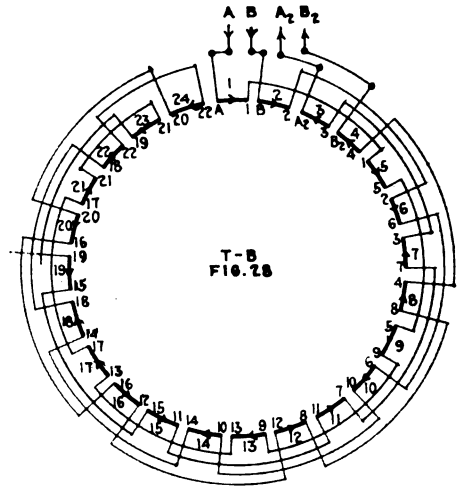
Top-to-Bottom. See Fig. 28

1 Series	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 7	4 8	5 9	6 10	7 11	8 12	9 13	10 14	11 15	12 16	13 17	14 18	15 19	16 20	17 21	18 22	19 21	20 22
2 Parallel	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 7	4 8	5 9	6 10	7 11	8 12	9 13	10 14	11 15	12 16	13 17	14 18	15 19	16 20	17 A_2	18 B_2	19 A	20 B
3 Parallel	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 7	4 8	5 9	6 10	7 11	8 12	9 A_2	10 B_2	11 A	12 B	A 17	B 18	A_2 19	B_2 20	17 21	18 22	19 21	20 22
4 Parallel	A 1	B 2	A_2 3	B_2 4	1 5	2 6	3 7	4 8	5 A_2	6 B_2	7 A	8 B	A 13	B 14	A_2 15	B_2 16	13 17	14 18	15 19	16 20	17 A_2	18 B_2	19 A	20 B
6 Parallel	A 1	B 2	A_2 3	B_2 4	1 A_2	2 B_2	3 A	4 B	A 9	B 10	A_2 11	B_2 12	9 A_2	10 B_2	11 A	12 B	A 17	B 18	A_2 19	B_2 20	17 A_2	18 B_2	19 A	20 B
12 Parallel	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B

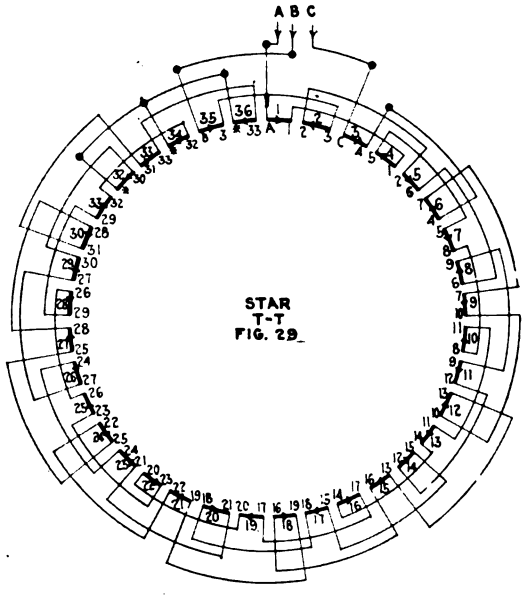
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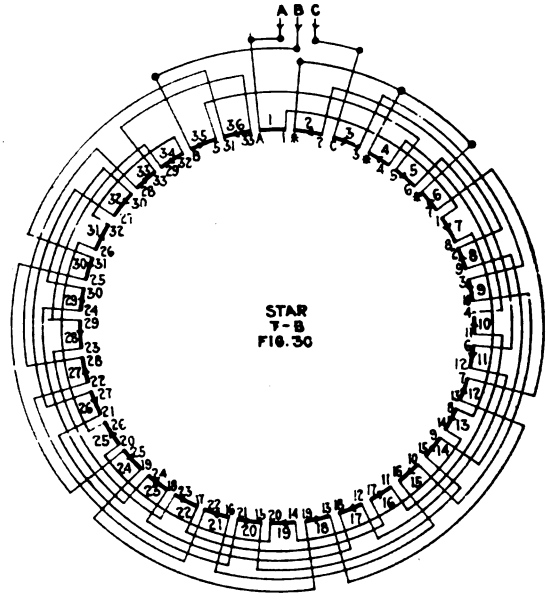
Twelve-Pole Windings

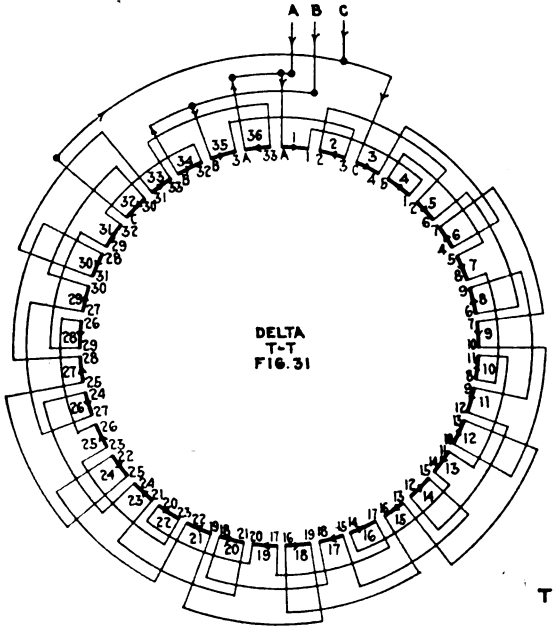


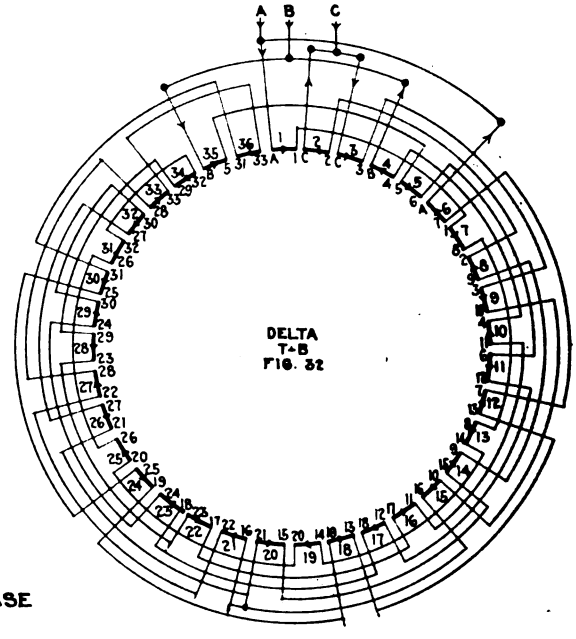


TWO - PHASE









THREE - PHASE

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Twelve-Pole, Three-Phase Windings

UNEQUAL COIL GROUPING—CHART N. TOP-TO-TOP

No. Coils	Group Numbers																							
	1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36
48	2k 1 1	1 1 2	1 2 1	2 1 1	1 1 2k	1 2 1	2 1 1	1 1 2	1 2k 1	2 1 1	1 1 2	1 2 1
54	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1	2 1 2	1 2 1
60	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2
62	1 2 2	2 2 1	2 2–1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	2–1 2 2	2 2 1	2 1 2
80	3 2 2	2 3–1 2	2 2 3	2 2 2	2 3 2	2 2 2	3 2 2	2 2 3–1	2 2 3	2 2 2	2 3 2	2 2 2
84	3k 2 2	2 2 3	2 3 2	3 2 2	2 2 3k	2 3 2	3 2 2	2 2 3	2 3k 2	3 2 2	2 2 3	2 3 2
86	3k 2 2	2 2 3	2 3 2	3 2 3–1	2 2 3k	2 3 2	3 2 2	3–1 2 3	2 3k 2	3 2 2	2 2 3	2 3 2
90	3k 2 3	2 3 2	3 2 3k	2 3k 2	3 2 3	2 3 2	3k 2 3	2 3 2	3 2 3k	2 3k 2	3 2 3	2 3 2
96	2 3k 3	3 3 2	3 2 3	2 3 3k	3k 3 2	3 2 3	2 3k 3	3 3 2	3 2 3	2 3 3k	3k 3 2	3 2 3
104	2 3k 3	3 3 3	3 3 2	3 3 3k	3k 3–1 3	3 3 3	2 3k 3	3 3 3	3 3 3–1	3 3 3k	3k 2 3	3 3 3
120	4k 3 3	3 3 4	3 4 3	4 3 3	3 3 4k	3 4 3	4 3 3	3 3 4	3 4k 3	4 3 3	3 4 3	3 4 3
128	4k 3 4k	3 4 3	4 4–1 4	3 4k 3	4 3 4	3 4 3	4k 3 4k	3 4 4–1	4 3 4	3 4k 3	4 3 4	3 4 3
135	3 4 4	4 3 4	4 4 3	4 4 4k	3 4 4	4 3 4	4 4 3	4 4k 4	3 4 4	4 3 4	4 4 3	4k 4 4
150	5k 4 4	4 4 4	4 4 5k	4 4 4	4 5k 4	4 4 4	5k 4 4	4 4 4	4 4 5k	4 4 4	4 5k 4	4 4 4
156	5k 4 4	4 4 5	4 5 4	5 4 4	4 4 5k	4 5 4	5 4 4	4 4 5	4 5k 4	5 4 4	4 4 5	4 5 4
160	5k 4 5–1	4 4 5	4 5 4	5 5–1 4	4 4 5k	4 5 4	5 4 5–1	4 4 5	4 5k 4	5 4 5–1	4 4 5	4 5 4
168	4 5k 5	5 5 4	5 4 5k	4 5 5	5k 5 4	5 4 5	4 5k 5	5 5 4	5 4 5k	4 5 5	5k 5 4	5 4 5
240	6 7k 7	7 7 6	7 6 7k	6 7 7	7k 7 6	7 6 7	6 7k 7	7 7 6	7 6 7k	6 7 7	7k 7 6	7 6 7

k A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Star, Top-to-Top. See Fig. 29

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	* 12	13 16	* 14	B 18	* 16
3 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	* 6	7 10	* 8	B 12	* 10	A 14	15 12	C 16	17 14	15 18	19 16
4 Parallel	A 1	2 3	C 4	5 1	2 *	7 4	5 *	9 B	7 *	11 A	9 12	13 C	11 14	* 12	13 16	* 14	B 18	* 16
6 Parallel	A 1	* 3	C 4	* 1	B 6	* 4	A 8	* 6	C 10	* 8	B 12	* 10	A 14	* 12	C 16	* 14	B 18	* 16
12 Parallel	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C

Group No.	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	* 30	31 33	* 32	B 3	* 33
2 Parallel	A 20	21 18	C 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	* 30	31 33	* 32	B 3	* 33
3 Parallel	17 20	* 18	19 22	* 20	B 24	* 22	A 26	27 24	C 28	29 26	27 30	31 28	29 32	* 30	31 33	* 32	B 3	* 33
4 Parallel	A 20	21 18	C 22	23 20	21 *	25 22	23 *	27 B	25 *	29 A	27 30	31 C	29 32	* 30	31 33	* 32	B 3	* 33
6 Parallel	A 20	* 18	C 22	* 20	B 24	* 22	A 26	* 24	C 28	* 26	B 30	* 28	A 32	* 30	C 33	* 32	B 3	* 33
12 Parallel	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C

Delta, Top-to-Top. See Fig. 31

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	C 12	13 16	B 14	B 18	A 16
3 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	C 6	7 10	B 8	B 12	A 10	A 14	15 12	C 16	17 14	15 18	19 16
4 Parallel	A 1	2 3	C 4	5 1	2 C	7 4	5 B	9 B	7 A	11 A	9 12	13 C	11 14	C 12	13 16	B 14	B 18	A 16
6 Parallel	A 1	C 3	C 4	B 1	B 6	A 4	A 8	C 6	C 10	B 8	B 12	A 10	A 14	C 12	C 16	B 14	B 18	A 16
12 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

Group No.	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	C 30	31 33	B 32	B 3	A 33
2 Parallel	A 20	21 18	C 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	C 30	31 33	B 32	B 3	A 33
3 Parallel	17 20	C 18	19 22	B 20	B 24	A 22	A 26	27 24	C 28	29 26	27 30	31 28	29 32	C 30	31 33	B 32	B 3	A 33
4 Parallel	A 20	21 18	C 22	23 20	21 C	25 22	23 B	27 B	25 A	29 A	27 30	31 C	29 32	C 30	31 33	B 32	B 3	A 33
6 Parallel	A 20	C 18	C 22	B 20	B 24	A 22	A 26	C 24	C 28	B 26	B 30	A 28	A 32	C 30	C 33	B 32	B 3	A 33
12 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

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Twelve-Pole, Three-Phase Windings

UNEQUAL COIL GROUPING—CHART N, TOP-TO-BOTTOM

No. Coils	Group Numbers																							
	1 2 3	4 5 6	7 8 9	10 11 12	13 14 15	16 17 18	19 20 21	22 23 24	25 26 27	28 29 30	31 32 33	34 35 36
48	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1	2 1 1	1 1 2	1 2 1
54	2 1 2	1 2 1	1 2 1	2 1 2	2 1 2	1 2 1	1 2 1	2 1 2	2 1 2	1 2 1	1 2 1	2 1 2
60	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2
62	1 2 2	2 2 1	2 2–1 2	1 2 2	2 2 1	2 1 2	1 2 2	2 2 1	2 1 2	3–1 2 2	2 2 1	2 1 2
80	3 2 2	2 3–1 2	2 3 2	2 2 2	2 2 3	2 2 2	3 2 2	2 3–1 2	2 3 2	2 2 2	2 2 3	2 2 2
84	3 2 2	2 2 3	2 3 2	3 2 2	2 2 3	2 3 2	3 2 2	2 2 3	2 3 2	3 2 2	2 2 3	2 3 2
90	3 2 3	2 3 2	2 3 2	3 2 3	3 2 3	2 3 2	2 3 2	3 2 3	3 2 3	2 3 2	2 3 2	3 2 3
96	2 3 3	3 3 2	3 2 3	2 3 3	3 3 2	3 2 3	2 3 3	3 3 2	3 2 3	2 3 3	3 3 2	3 2 3
104	2 3 3	3 3 3	3 3–1 3	3 3 3	3 3 2	3 3 3	2 3 3	3 3 3	3 2 3	3 3 3	3 3 3–1	3 3 3
120	4 3 3	3 3 4	3 4 3	4 3 3	3 3 4	3 4 3	4 3 3	3 3 4	3 4 3	4 3 3	3 3 4	3 4 3
128	4 3 4	3 4 3	3 4 3	4 4–1 4	4 3 4	3 4 3	4 3 3	4 3 4	4 4–1 4	3 4 3	3 4 3	4 3 4
135	3 4[k] 4	4 3 4[k]	4 4 3	4[k] 4 4	3 4[k] 4	4 3 4[k]	4 4 3	4[k] 4 4	3 4[k] 4	4 3 4[k]	4 4 3	4[k] 4 4
150	5[k] 4 4	4 4 4	4 5[k] 4	4 4 4	4 4 5[k]	4 4 4	5[k] 4 4	4 4 4	4 5[k] 4	4 4 4	4 4 5[k]	4 4 4
156	5 4 4	4 4 5	4 5 4	5 4 4	4 4 5	4 5 4	5 4 4	4 4 5	4 5 4	5 4 4	4 4 5	4 5 4
160	4 5 4	5-1 4 5	5 4 5	4 4 4	4 4 4	5 5-1 4	5 4 5-1	4 5 4	4 5 4	5 4 5	5-1 4 5	4 5 4
168	4 5 5	5 5 4	5 4 5	4 5 5	5 5 4	5 4 5	4 5 5	5 5 4	5 4 5	4 5 5	5 5 4	5 4 5
240	6 7 7	7 7 6	7 6 7	6 7 7	7 7 6	7 6 7	6 7 7	7 7 6	7 6 7	6 7 7	7 7 6	7 6 7

[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Star, Top-to-Bottom. See Fig. 30

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19
2 Parallel	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19
3 Parallel	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 *	13 19
4 Parallel	A 1	* 2	C 3	* 4	5 6	* 7	1 8	2 9	3 10	4 11	6 *	7 13	8 *	9 B	10 *	11 A	B 18	13 C
6 Parallel	A 1	* 2	C 3	* 4	5 *	* 7	1 *	2 B	3 *	4 A	B 12	7 C	A 14	* 15	C 16	* 17	12 *	* 19
12 Parallel	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C

Group No.	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 27	22 28	23 29	24 30	25 31	26 32	27 30	28 33	29 32	B 5	31 33
2 Parallel	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 27	22 28	23 29	24 *	25 31	26 *	27 B	28 *	29 A	B 5	31 C
3 Parallel	14 *	15 B	16 *	17 A	B 24	19 C	A 26	* 27	C 28	* 29	24 30	* 31	26 32	27 30	28 33	29 32	B 5	31 33
4 Parallel	A 20	* 21	C 22	* 23	18 24	* 25	20 26	21 27	22 28	23 29	24 *	25 31	26 *	27 B	28 *	29 A	B 5	31 C
6 Parallel	14 *	15 B	16 *	17 A	B 24	19 C	A 26	* 27	C 28	* 29	24 *	* 31	26 *	27 B	28 *	29 A	B 5	31 C
12 Parallel	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C

Delta, Top-to-Bottom. See Fig. 32

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Series	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19
2 Parallel	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 18	13 19
3 Parallel	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 12	7 13	8 14	9 15	10 16	11 17	12 C	13 19
4 Parallel	A 1	C 2	C 3	B 4	5 6	A 7	1 8	2 9	3 10	4 11	6 C	7 13	8 B	9 B	10 A	11 A	B 18	13 C
6 Parallel	A 1	C 2	C 3	B 4	5 C	A 7	1 B	2 B	3 A	4 A	B 12	7 C	A 14	C 15	C 16	B 17	12 C	A 19
12 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

Group No.	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Series	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 27	22 28	23 29	24 30	25 31	26 32	27 30	28 33	29 32	B 5	31 33
2 Parallel	14 20	15 21	16 22	17 23	18 24	19 25	20 26	21 27	22 28	23 29	24 C	25 31	26 B	27 B	28 A	29 A	B 5	31 C
3 Parallel	14 B	15 B	16 A	17 A	B 24	19 C	A 26	C 27	C 28	B 29	24 30	A 31	26 32	27 30	28 33	29 32	B 5	31 33
4 Parallel	A 20	C 21	C 22	B 23	18 24	A 25	20 26	21 27	22 28	23 29	24 C	25 31	26 B	27 B	28 A	29 A	B 5	31 C
6 Parallel	14 B	15 B	16 A	17 A	B 24	19 C	A 26	C 27	C 28	B 29	24 C	A 31	26 B	27 B	28 A	29 A	B 5	31 C
12 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

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Rules for Working Out Various Arrangements of Coils in Groups

Rule I—Divide the number of coils by the number of groups. The number of groups equals the number of poles multiplied by the number of phases.

(a) If this division gives a whole number as a quotient, then the groups will all be equal, and have the number of coils represented by this whole number.

(b) If this division does not come out even, pass to Rule II.

Rule II—Divide the number of coils by the number of circuits. The number of circuits equals the number of phases multiplied by the number of parallel paths. For instance, a three-phase, two-parallel winding has six circuits.

(a) If the quotient of this division is a whole number, no coils need be killed. Then pass to Rule IV.

(b) If the division leaves a remainder, then coils must be killed equal in number to the remainder. Suppose, for instance, there are eight circuits and ninety coils. Then 90÷8=11 and a remainder of 2. This means two coils must be killed. If the number of killed coils exceeds 8 per cent of all the coils, the winding should not be used to carry its normal rated load in horsepower. The number of turns per slot should be increased, if possible, without reducing the wire size.

In killing coils the coils to be killed should be chosen at points as nearly equidistant from each other as possible around the stator. At the same time the dead coils must be as equally distributed as possible among the different phases. After the coils have been killed the winding is treated as a winding in which no coils are killed. The number of coils now is equal to the number of active coils (the total number minus the number killed.) Then pass to Rule III.

Rule III—Divide the number of active coils by the number of groups.

(a) If the quotient comes out a whole number then each group will have that many active coils.

(b) If there is a remainder left after the division, the grouping will be unequal. Pass to Rule IV.

Rule IV—On dividing the number of active coils by the number of groups, there will be a quotient and a remainder. For instance, dividing 90 coils by 24 groups we get 90÷24=3 (the quotient) plus a remainder of 18. Then in this case 18 of the groups will each have 3 (the quotient) +1, or 4, coils; and the other groups (24—18=6 groups) will have 3 coils each.

These groups must be arranged so that each phase has the same number of active coils; also so that the larger groups are distributed as evenly as possible around the winding. Different methods of getting a good arrangement are explained further on by means of examples.

Table II—Locating Unequal Coil Groupings

This is a six-pole three-phase winding with twenty-four coils

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Phase	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Large groups, pitch 1 and 4	X			X			X			X			X			X		
Large groups, relocated	X					X		X		X					X		X	
Phase after relocating	A					C		B		A					C		B	
Grouping, top-to-top	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	2	1

Table I—For Locating Large Groups in Unequal Grouping

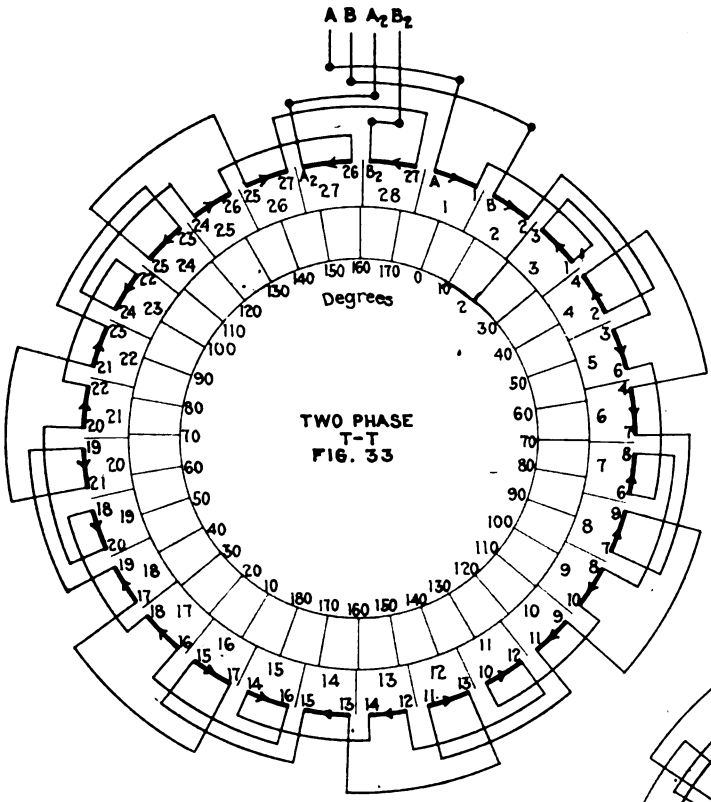
This table shows how various combinations of large and small groups are placed. It refers to the Charts in which groupings may be found similar to most cases which will occur. The number of large groups equals the remainder left after dividing the total number of coils by the total number of groups. For sixteen to twenty-four poles the numbers showing the proportion of large to small groups are included in the charts showing unequal coil groupings.

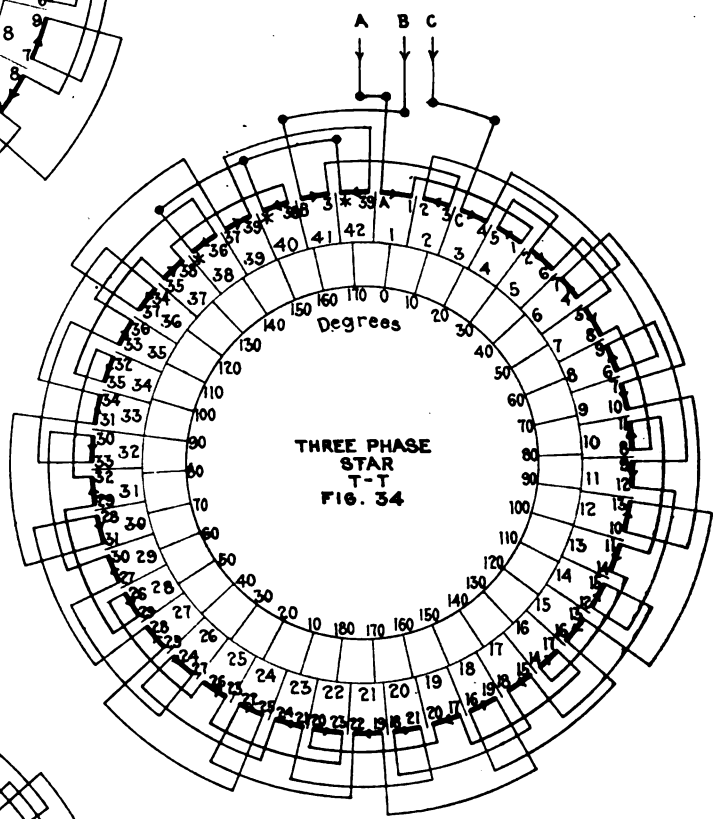
No. of Poles	No. of Phases	No. of Large Groups	No. of Small Groups	Like Winding with No. of Coils Shown Below	Refer to Chart
2	2	2	2	18	A
	3	2	4	62	B
4	2	2	6	90	C
		4	4	12	
		6	2	54	
		7	1	135	
	3	2	10	62	D
		3	9	135	
		4	8	160	
		6	6	18	
		8	4	80	
6	2	2	10	62	E
		3	9	135	
		4	8	104	
		6	6	18	
		8	4	80	
	3	2	16	128	F
		6	12	24	
		8	10	62	
		9	9	135	
		12	6	48	
		14	4	86	
		16	2	160	
3	2	4	12	36	G
		6	10	54	
		7	9	135	
		8	8	24	
		10	6	90	
		12	4	60	
		14	2	62	
8	3	6	18	54	H
		8	16	80	
		12	12	36	
		14	10	62	
		15	9	135	
		16	8	160	
	2	2	18	62	K
		4	16	84	
		6	14	86	
		8	12	48	
		10	10	90	
		12	8	72	
		14	6	54	
		15	5	35	
		16	4	96	
10	3	2	28	62	L
		6	24	96	
		8	22	128	
		10	20	160	
		12	18	72	
		14	16	104	
		15	15	135	
		18	12	48	
		20	10	80	
		24	6	54	
		26	4	86	
12	2	6	18	54	M
		8	16	80	
		9	15	135	
		10	14	62	
		12	12	36	
		14	10	80	
		16	8	160	
		18	6	90	
12	3	6	30	150	N
		8	28	80	
		12	24	48	
		14	22	86	
		16	20	160	
		18	18	54	
		20	16	128	
		24	12	168	
		26	10	62	
		27	9	135	
		32	4	104	
14	2	4	24	60	P
		6	22	62	
		8	20	36	
		10	18	150	
		12	16	96	
		16	12	72	
		20	8	48	
		23	5	135	
		24	4	80	
		26	2	54	
	3	2	40	86	X
		6	36	48	
		9	33	135	
		12	30	54	
		18	24	60	
		20	22	62	
		24	18	108	
		30	12	72	
		34	8	160	
		36	6	120	
		38	4	80	

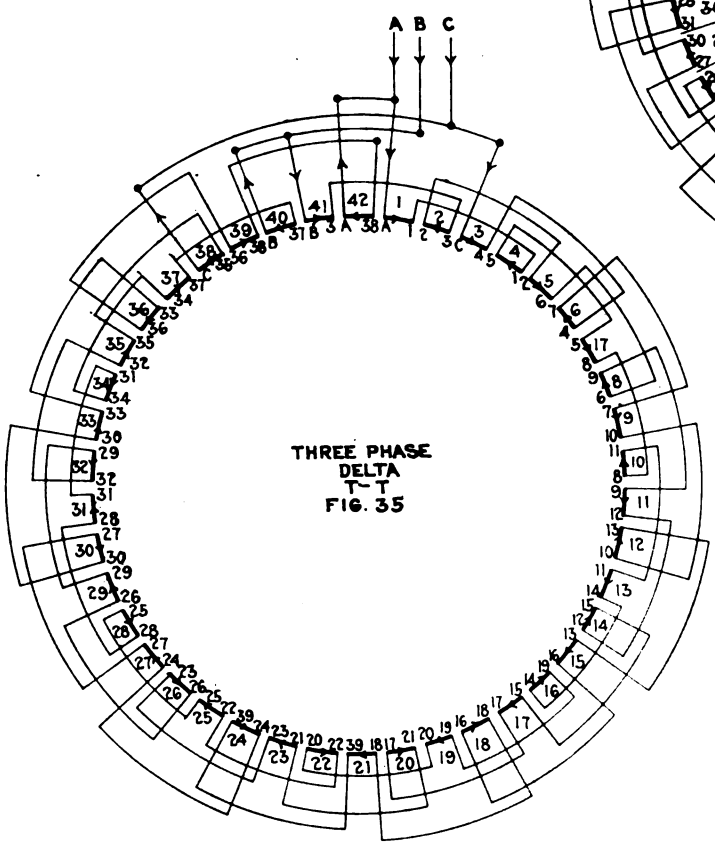
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Fourteen-Pole Windings

See Tables for Connecting Ends of Groups and for Unequal Coil Grouping on pages 207 and 224.







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Some Examples Showing How to Group the Coils

In the following paragraphs are given some examples which will explain clearly the rules on page 205.

Example for Rule I—(a):

Suppose we have a winding with 90 coils and want to connect it for a three-phase, six-pole series winding. According to Rule I the first thing to do is to divide the number of coils by the number of groups. The number of groups in this case is 3 × 6 or 18. Dividing 90 coils by 18 groups we get an answer of five without any remainder. In this case, then, the groups will all have five coils each.

Example of Rule I—(b):

Suppose now we have a winding with 90 coils and we want to get a twelve-pole, three-phase two-parallel connection. According to Rule I, we divide the number of coils by the number of groups. The number of groups in this case equals 3 × 12 or 36. Dividing 90 by 36 we get a remainder and, therefore, according to (b) of Rule I we must pass on to Rule II. This remainder means that coils must be killed or that we must use an unequal grouping.

Example of Rule II—(a):

We now take the winding of 90 coils, mentioned in the last paragraph, and divide the number of coils by the number of circuits. The number of circuits equals the number of phases multiplied by the number of parallel paths, which in this case equals three phases multiplied by two parallel paths. This amounts to six circuits. Dividing 90 by 6 we get 15 without any remainder, and, therefore, according to (a) of Rule II, no coils need be killed. Consequently, according to (a) of Rule II, we pass on to Rule IV.

Following Rule IV, when we divide the number of coils by the number of groups we find that we have a remainder. With twelve poles and three phases, we have 36 groups, and dividing 90 by 36, we get an answer of 2 plus a remainder of 18. This means that 18 of the groups will each have 2 plus 1, or 3 coils. Then the remainder of the groups, which equals 36 minus 18, or 18 groups, will each have 2 coils. The method of arranging the large coils is explained in the paragraphs following the Example for Rule IV—(b).

Example of Rule II—(b):

Suppose now we have a winding with 62 coils and want to get a ten-pole, three-phase, two-parallel winding. According to Rule II we divide the number of coils by the number of circuits. There are six circuits (3 phases × 2-parallel). Dividing 62 by 6 we get a remainder of 2. Then two coils must be killed. We can kill one coil in the *A* phase in Group 1. The next coil should be killed about half-way around the winding, or in Group 16, as there are thirty groups. This coil should be in either the *B* or *C* phase. If three coils had to be killed they would be spaced one-third way around in *A*, *B* and *C* phases. Four dead coils would be one-fourth way around, and so on.

Now suppose it was desired to connect this 62-coil winding for an eight-pole, three-phase, eight-parallel winding. According to Rule II we divide the number of coils, 62, by the number of circuits. The number of circuits equals 3 × 8 or 24. Dividing 62 by 24 we get a remainder of 14. This means that fourteen coils would be killed. This is 23 per cent of the total number of coils, but not over 8 per cent should be killed, according to Rule II—(b). Therefore, such a connection is not practicable.

Example of Rule III—(a):

Suppose we have the 62-coil winding and *(Continued on page 225.)*

Fourteen-Pole Windings

CONNECTIONS FOR ENDS OF GROUPS

Connect together group ends having same number or letter. Line leads are indicated by letters. A star connection is shown by (*).

Two-Phase, Top-to-Top. See Fig. 33

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series	A 1	B 2	3 1	4 2	3 6	4 7	8 6	9 7	8 10	9 11	12 10	13 11	12 14	13 15
2 Parallel	A 1	B 2	3 1	4 2	3 6	4 7	8 6	9 7	8 10	9 11	12 10	13 11	12 A_2	13 B_2
7 Parallel	A 1	B 2	A_2 1	B_2 2	A 6	B 7	A_2 6	B_2 7	A 10	B 11	A_2 10	B_2 11	A 14	B 15
14 Parallel	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2

Group No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Series	16 14	17 15	16 18	17 19	20 18	21 19	20 22	21 23	24 22	25 23	24 26	25 27	A_2 26	B_2 27
2 Parallel	16 A	17 B	16 18	17 19	20 18	21 19	20 22	21 23	24 22	25 23	24 26	25 27	A_2 26	B_2 27
7 Parallel	A_2 14	B_2 15	A 18	B 19	A_2 18	B_2 19	A 22	B 23	A_2 22	B_2 23	A 26	B 27	A_2 26	B_2 27
14 Parallel	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B

Three-Phase Star, Top-to-Top. See Fig. 34

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12
7 Parallel	A 1	* 3	C 4	* 1	B 6	* 4	A 8	* 6	C 10	* 8	B 12	* 10	A 14	* 12
14 Parallel	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B

Group No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Series	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26
2 Parallel	13 16	17 14	15 *	19 16	17 *	21 B	19 *	23 A	21 24	25 C	23 26	27 24	25 28	29 26
7 Parallel	C 16	* 14	B 18	* 16	A 20	* 18	C 22	* 20	B 24	* 22	A 26	* 24	C 28	* 26
14 Parallel	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A

Group No.	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Series	27 30	31 28	29 32	33 30	31 34	35 32	33 36	37 34	35 38	* 36	37 39	* 38	B 3	* 39
2 Parallel	27 30	31 28	29 32	33 30	31 34	35 32	33 36	37 34	35 38	* 36	37 39	* 38	B 3	* 39
7 Parallel	B 30	* 28	A 32	* 30	C 34	* 32	B 36	* 34	A 38	* 36	C 39	* 38	B 3	* 39
14 Parallel	B *	* C	A *	* 3	C *	* A	B *	* C	A *	* B	C *	* A	B *	* C

Three-Phase Delta, Top-to-Top. See Fig. 35

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12
2 Parallel	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12
7 Parallel	A 1	C 3	C 4	B 1	B 6	A 4	A 8	C 6	C 10	B 8	B 12	A 10	A 14	C 12
14 Parallel	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B

Group No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Series	13 16	19 14	15 17	18 16	19 20	21 17	18 39	22 20	21 23	24 39	22 25	26 23	24 27	28 25
2 Parallel	13 16	19 14	15 C	18 16	19 B	21 B	18 A	22 A	21 23	24 C	22 25	26 23	24 27	28 25
7 Parallel	C 16	B 14	B 17	A 16	A 20	C 17	C 22	B 20	B 23	A 22	A 25	C 23	C 27	B 25
14 Parallel	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A

Group No.	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Series	26 29	30 27	28 31	32 29	30 33	34 31	32 35	36 33	34 37	C 35	36 38	B 37	B 3	A 38
2 Parallel	26 29	30 27	28 31	32 29	30 33	34 31	32 35	36 33	34 37	C 35	36 38	B 37	B 3	A 38
7 Parallel	B 29	A 27	A 31	C 29	C 33	B 31	B 35	A 33	A 37	C 35	C 38	B 37	B 3	A 38
14 Parallel	B C	A C	A B	C B	C A	B A	B C	A C	A B	C B	C A	B A	B C	A C

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, April, 1923

Are Your Men Making Bricks Without Straw?

AN unfortunate situation which exists in the executive control of maintenance in a large industrial works and is duplicated in many smaller plants, is recorded here as a subject which is well worth careful consideration by those who have the power to create or remedy similar conditions in their own works. In the plant in question the maintenance foreman reports to an executive who is not, by instinct or training, an engineer. He can reduce a lengthy financial statement to its simplest terms, but has little understanding of, and less sympathy for, maintenance work and all that it involves. To him maintenance is merely a necessary evil. So long as a motor will run why bother about inspecting it regularly or painting the field coils or changing the oil in the bearings or doing any of the other things which maintenance men do? The natural result of this attitude of mind is a policy which hampers and obstructs in every way. It is discouraging rather than encouraging to honest endeavor. Under such conditions it is hard for the men to feel much loyalty for the job or for the company. In consequence, both men and company are suffering.

Perhaps maintenance work is a costly evil, but unless manufacturers reach the present hopeless ideal condition whereby they can build equipment which will operate indefinitely without any attention whatever, there will be need for inspection and repairmen. And until that time comes the way to relative freedom from interruptions of power service, low operating costs and small repair bills will be in the detection and remedy of trouble signals the first time they show up and most certainly before a second warning signal appears.

An attempt was made many years ago to make bricks without straw, but the results were not altogether satisfactory—nor are they any more satisfactory today. Moreover, a successful animal trainer has said, "You can't teach animals unless they like you—men in general, take notice!" We would use ditto marks for all except the last, which would fit better if it read "executives, take notice," for we all have some animal instincts, particularly in connection with likes and dislikes toward those who appreciate or ignore an intense interest in and an honest endeavor to do something worth while when the possible results are apparent and worthy of the effort.

A Bald Fact—We Pay For What We Need

A BALD-HEADED man pays the full price for a haircut, even though the acreage in hair is very small compared to the barren portion. Doubtless he feels that he is being imposed upon, and perhaps he is, but it is merely the penalty he pays for being bald. Not all of us are bald, but we are often blind to the fact that we usually pay in one way or another for the things we need, whether we get them or not. We may think that money is being saved by keeping in service obsolete or inefficient equipment or refusing to buy equipment which will enable more and better work to be done in a given period. A careful study will, however, often show that through heavy maintenance and repair charges and the loss of production through breakdowns or operation at less than maximum output, we are paying for the new equipment which should replace the old.

It may appear that money is being saved by not spending it for washing or cleaning bulbs and reflectors, replacing blackened or burned-out bulbs and doing the other maintenance work which must be given to a lighting system in order to keep it at its highest efficiency. Although the payroll may not contain the name of a lamp washer, payment for this service is nevertheless made in more accidents, reduced output of workmen, greater spoilage of materials and so on. Instances of this nature could be multiplied almost indefinitely. Nearly every industrial works carries an invisible, but very real, payroll and plant account in which are entered the wages of the men who are needed but not hired and the cost of equipment that is needed but not purchased. Invisible accounts they are, but they absorb many hard and very real dollars that do not appear in the inventory or among the assets. That is the penalty we pay for being blind.

Power Costs in Payroll Dollars

THE PRACTICE of swapping dollars and otherwise juggling mental conceptions of absolutely equal values is a small boy trait found in many of us old enough to know better. But it seems to be such great fun at times that a considerable expenditure is necessary to straighten out the resulting complications in bookkeeping. Such expenditures together with the actual losses that are discovered are then charged as operating expenditures. If there were an item in the ledger account headed "Small Boy Profits and Losses" some grown men might learn a lot about themselves.

Let's discuss for a moment the subject of power as something bought and used in the manufacture of, say a sack of cement, a jackknife, or anything else. We will assume that the production equipment is installed and ready to turn out the product. The first large item to consider is the raw stock needed, second, the labor to handle this at machines in production processes and, third, the power necessary to operate the machines and keep the labor busy. Raw material when paid for by

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the pound can be weighed. Labor when paid for by the hour is a known expenditure at the start. But power —you pay for what you use after you use it and you depend upon the integrity of labor and those who supervise it to reach into an unlimited supply and use or waste it in proportion to their ability to exercise good judgment. And by this use of power the expenditure for labor is converted into a commodity and its actual cost or value must be measured by productiveness expressed in a combination of machine- and man-hours.

Without following this thought further, it is plain that power costs are paid for with the same kind of dollars that must be put into the labor pay envelopes. For this reason guesswork in the estimates and control of the amount of power used should not be tolerated any more than guesswork in making up the amount of the labor payroll. As a matter of fact, power costs can be computed per pound of plant output or per yard of cloth made or per gross of jackknives and when so analyzed it will be discovered that it is one of the cheapest of elements in the product when ready to ship if average efficiency is maintained in production processes. Because power is cheap it should not on the other hand be wasted but liberally substituted for operations that are wasteful of materials and labor and for speeding up operations so that labor will be more productive and a just and equitable rate can be paid for it on that basis.

Simple ways are available for checking up power requirements in manufacturing processes and distributing the charges. Mr. Whitcomb in this issue shows this through a system of metering that means as much to a system of power distribution as an adding machine means to an efficient bookkeeping system. Just as the adding machine checks up errors of simple addition so also the meters check up errors of manipulation and judgment in estimates on the use of power in production processes. Such meters do not represent fanciful ideas nor available expenditures. They are the same marks of good business sense that a cash register represents when placed where money in small amounts both goes out and comes in.

Those Home-Made Tools

IT is frequently said that the hobby of practical men is the home-made device or tool. And if it were a crime to have a hobby it is probable that a great many convictions might be made on this score. But it's fortunate that no such seriousness can be attached to this charge. On the contrary, to the operator who displays his ingenuity and initiative in doing things in a different and better way, nothing short of the greatest respect and credit is due. Now and then a device is made that is similar to one that is available at a smaller cost than it requires to make it by hand, but in many more cases new ideas and improvements in the ways of doing things spring from these home-made products. And if the manufacturer who makes it his business to manufacture such devices is on his job, he sees in these home-made devices the expressions of service needs that he could not secure otherwise except through much expensive experimenting and development work.

In establishing the department "Service Around the Works" in INDUSTRIAL ENGINEER it was the idea to provide a place for the recording of the ideas of practical men in the working out of ways of doing things that are out of the ordinary, that are forced upon them by emergencies and have called for all the ingenuity that could be mustered at the time. No one spots a makeshift method quicker than the operator with an inventive turn of mind and items that are lacking in ingenuity are promptly jumped on by such men in such a way as to call forth the reasons why the practice should be condemned in every way.

The thinking that brings forth the home-made product is a sign of real interest in improved ways of doing things and we feel that this thinking should be given full expression and encouragement rather than jealous or sarcastic comment by those whom it affects from a competitive sales standpoint.

Our Basic American Industries

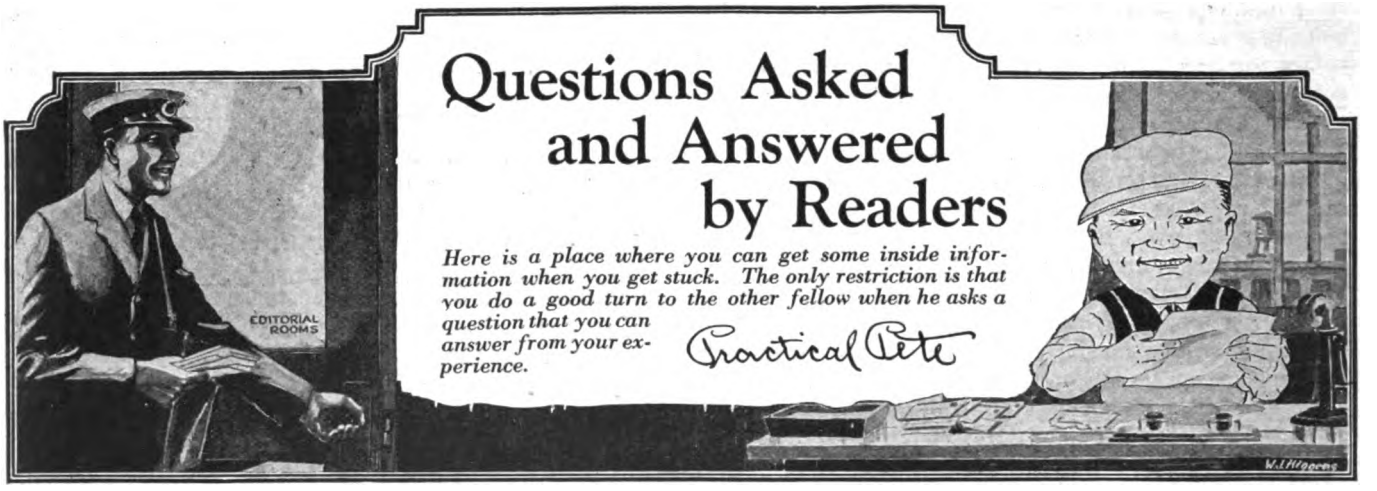
WORKERS in modern American industrial plants are frequently inclined to look at their own industry as all important and fail to see that it is only one link in the chain which binds and weaves all industries together. Probably no industry is sufficient unto itself alone. The steel industry, for example, is in reality a chain of industries beginning with the mining of the ore, its transportation to the blast furnaces and ending with its conversion into pig iron and into steel. Thousands of other industries are dependent upon the steel industry for their supply of raw material to be worked further into finished products. The finished product of one industry is the raw material of the next.

Articles made of steel alone are few. Our telephones, automobiles, radio sets, and many other conveniences and necessities consist merely of the assembly of steel, copper, fiber, cotton and dozens of other products into one article. The electrical and mechanical machinery which you use every day also represent an assembly of a variety of products from various industries.

In the frontispiece feature pages of the last issues of the INDUSTRIAL ENGINEER, particular attention has been given to the food industry. To the man who buys his bread and crackers at the neighboring grocery store or bakery, this industry may appear to be of little direct importance to him. However, it has been the developments in the manufacture of agricultural machinery and improvements in the machinery that makes it, which have made possible grain production with a minimum of labor, the milling of flour and its distribution, and the distribution of the finished product. The ease with which bakery bread, crackers, cookies and other delicacies can be obtained, has enabled workers to concentrate their efforts in the textile, iron and steel, shoe, copper or any of the other industries. In these they earn the money to buy what they want or need and are confident that they can get it when they want it. If men had to worry about where their food, clothes, shoes and other necessities were coming from, they could give less time or attention to their work.

Similarly industries are able, due to the concentration and specialization of industries, to buy what they need in the shape of raw material to keep their plants operating. It is the purpose of our frontispiece feature pages to emphasize this importance of the inter-relation of industries and to show the developments in growth which have resulted through the use of electrical and mechanical equipment and appliances that multiply the work of many hands and brains.

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Who Can Answer These?

Dielectric Constants for Insulation—In the February issue of INDUSTRIAL ENGINEER, J. B. Rakoske answered the question by L. E. G. and gave the dielectric constant for paper as 2. I would like to obtain a table of dielectric constants for all insulating materials used with motor windings. Perhaps this information has been compiled and some reader can tell me where to find it.
Brooklyn, N. Y. H. D. D.

* * * *

Locating Trouble in Wiring Circuit—I would appreciate suggestions from readers on the best scheme for testing B. X. wiring circuits for troubles such as short circuits and grounds, which does not require taking out switches and receptacles or dropping of canopies of lighting fixtures.
Brooklyn, N. Y. H. F.

* * * *

Commutator Connections for Electric Drill—I have an electric drill of the Universal type with an armature having 12 slots and a commutator of 24 bars. The leads are connected two bars to the right of the coil, and the brushes are set in the middle of the field pole. I would like to have some reader make up a diagram showing the complete winding and connections for this motor.
Belmont, N. Y. E. L. G.

* * * *

Changing Connections of Motor Fields—I would like to see a diagram showing exactly how to change a 220-volt d. c. motor for operation on 110 volts. The present speed is 900 r.p.m. and the rating of the motor is 60 hp. What will be the horsepower at 110 volts and the speed? Will it be necessary to change the armature winding? If so, please indicate the changes necessary. The motor has six field coils.
Emaus, Pa. J. A. K.

* * * *

Starting Trouble When Rheostat Was Changed—I have a 2-hp., 230-volt motor connected to a drill press. The rheostat burned out recently and I made use of a 5-hp., 115-volt rheostat which was all we had. When starting the motor with this rheostat it ran in the wrong direction. We tried to reverse the direction by changing the armature leads and changing the field leads. This did not change the direction of rotation. The motor is a two-pole type shunt wound. Please advise why the direction of rotation was not changed when changing the connections and also how the direction of rotation can be changed.
Indianapolis, Ind. H. T. F.

* * * *

How to Secure 110- and 220- Volt Service from 220-Volt Generator—We have a 7.5 kva., 3-phase, 220-volt, 60-cycle self-excited a. c. generator that we desire to use at night for lighting the boiler and turbine room and some residences across the street. I would like to have some reader tell me what transformer connections I can use to obtain 110 or 120 volts on the secondary side, so as to balance the load on all three phases. Would it be possible to use a balance coil with a three-wire secondary? If so, I would like to see a diagram of connections that will be most satisfactory.
Henderson, Ky. J. M.

* * * *

Size of Equalizer Cable—What is the ratio of the size of an equalizer cable to the positive cable of a 100-kw. d. c. generator? Suppose two generators, one of 100-kw. and the other of 500 kw. are to be used together. What would be the size of the two equalizer cables and how is this size determined?
Lima, Ohio. J. E. B.

* * * *

Trouble with Type C Mazda Lamps—During the last few months I have been having trouble with 100- and 200-watt, type C, Mazda lamps burning out. In about 50 per cent of the cases when the 200-watt lamp burns out, it short circuits where the lead wires go through the inner glass tube down to the filament. I have had four cases where the outside globe has been bursted. When this trouble started, I thought it was due to vibration but have since found that this is not the cause as lamps attached to heavy I-beams show the same trouble. This trouble does not occur quite as often with the 100-watt lamps. In both cases when this trouble comes up the fuses in the circuit are blown. Our operating voltage is 230 d. c. and we use 240-volt lamps. Has anyone experienced this trouble and found a remedy?
New Orleans, La. P. B. A.

Answers Received To Questions Asked

The following is submitted to answer the questions on page 158 of the March issue of INDUSTRIAL ENGINEER.

Question by L. S.: Refer to a wire table where you will find a No. 14 wire contains 4106 circ. mils, 7 wires contain $7 \times 4106 = 28{,}742$ circ. mils. Refer again to the wire table where you will find No. 6 contains 26,250 circ. mils and No. 5 contains 33,102 circ. mils. The rating, therefore, falls between these two sizes.

Question by G. E. G.: Superservice cord as manufactured by the leading wire companies used with the Hayward spring-operated cable reel should prove satisfactory for this work. The writer is in touch with a dozen or more installations giving continuous service.

Question by F. R.: There is no reason why a remote starting installation would not be satisfactory. If provided with the proper meters the operator would be able to start more intelligently than by watching the motor. The proper way to start this equipment would be with automatic control operated by a push button. F. O. SCHNURE.
Assistant Supt. Electrical Dept.,
Bethlehem Steel Co.,
Sparrows Point, Md.

* * * *

I wish to make a slight correction in my article in the March, 1923, issue of INDUSTRIAL ENGINEER, entitled, "Testing Motor Field Coils."

The sentence in question reads, "If the coils are in good condition the application of a d. c. voltage across them and with the normal exciting current passing through them, will not cause the temperature rise to become rapid, but will show a gradual rise and a continued equal

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rise after the maximum is reached."

I find that this statement is somewhat misleading, and therefore submit a revision in the wording of this sentence, which would make it read as follows:

"If the coils are in good condition the application of a d. c. voltage across them and with the normal exciting current passing through them, will not cause the temperature rise to become rapid, but will show a gradual rise until the maximum temperature is reached, when the temperature will remain practically constant for the remainder of the test."

I regret that such a discrepancy appeared in the article, and trust that the correction will be made in a future issue so that readers may not be misinformed.

NATHANIEL W. BLANCHARD.
Inwood, L. I., N. Y.

* * * *

Charges for Maintenance Service—I have a number of motors which I am taking care of on a monthly basis. Please offer suggestions for a basis of rates for this service which has been found satisfactory in other locations.
Denver, Colo. W. C. M.

Regarding the inquiry of W. C. M. on charges for maintenance service, the undersigned has conducted a maintenance service along the line mentioned by W. C. M. extending over a period of two years and has devised a schedule of rates that has proven adequate. Fees are based on the individual motor, varying with size, type, accessibility, and type of control. An aggregate of all motor fees constitutes the monthly fee. Discounts are arranged for installations of over ten motors, and additions for installations of less than ten motors. Base rates take care of bi-monthly service with additions for weekly and deductions for monthly periods with a minimum rate for the small installations.

The popularity of the service may be judged from the fact that the only cancellations of service have been made with the idea of retrenchment. This came after we had succeeded in placing equipment in tip-top shape and, of course, those that we have dropped as deadbeats. At present we have one plant that is dispensing with the services of an electrician. Their claim is that we are lowering the electrical repair shop costs exclusive of labor.

Due to the schedule of rates being quite extensive space will not permit showing same. If W. C. M. will correspond with the writer, it will be a pleasure to aid him in making a success of his venture.

My estimate of the INDUSTRIAL ENGINEER may be seen from the fact that of four other publications to which I have subscribed I have let two expire and with the expiration of the third will not renew. It has the world beat for the practical man, so watch the circuits. Don't let her single phase and burn out and remember me to Practical Pete.

G. W. BARTHOLOMEW.
Industrial Electric Service of Erie, Erie, Pa.

* * * *

Stairway Wiring for Four-Story Building—I would like to see a wiring diagram published in INDUSTRIAL ENGINEER for the stairway in a four-story building. The lighting requirements are as follows: There should be only one light on each floor controlled by a switch on that floor. There must also be provided in addition to the switches on the second, third and fourth floors, switches so connected with those on the first floor that the first and second floor lights may be controlled from the first and second floors, and also so that the first, second and third floor lights may be controlled from the first and third floors. In like manner all four lights must be controlled from the first and fourth floors.
Worcester, Mass. H. P. J.

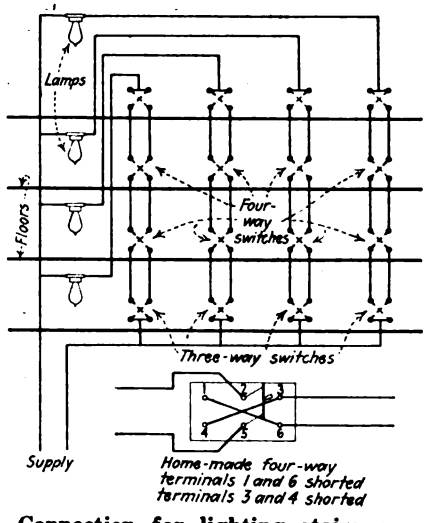
The following will answer H.P.J.'s request for a wiring diagram, in the December INDUSTRIAL ENGINEER.

By using standard three-way switches to control the light on each floor, and remote-control switches on the second, third and fourth floors operated by momentary-contact switches, he can control the first and second floors from the first and second floors; the first, second and third floors from the first and third floors, and the first, second, third and fourth from the first and fourth; also each floor from that floor.

W. W. PEASCOOD.
Chief Electrician,
American Beet Sugar Co.,
Oxnard, Cal.

* * * *

The exact circuit asked for is doubtful, but the accompanying diagram will cover it, as any light can be operated from any floor. If a switch is not needed simply omit it.



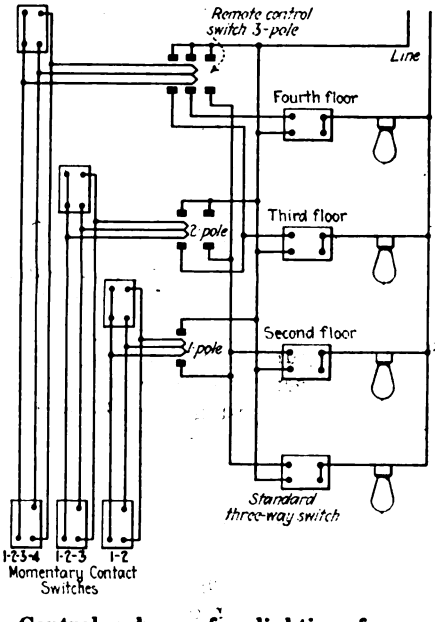
Connection for lighting stairs on four floors.

The end switches of each string are of the three-way type and the intermediate switches are four-way. A three-way is the same as a S. P. D. T. knife switch, and a four-way can be made of a D. P. D. T. knife switch as shown. R. M. BEECHER.

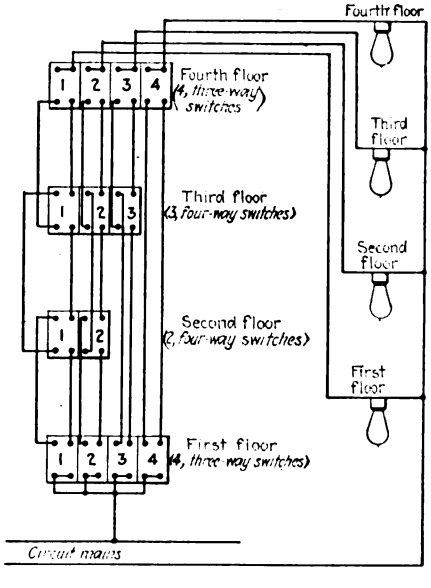
Canandaigua, N. Y.

* * * *

In the December issue of INDUSTRIAL ENGINEER, H. P. J. requests a diagram for a stair-lighting installation having various switching



Control scheme for lighting four floors.



Stairway lighting controlled from four floors.

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specifications. I am enclosing a rough sketch of the same as I interpret it. I trust that my interpretation is correct and that it will be of some assistance to H. P. J.

CHAS. D. BONEY.

Ebensburg, Pa.

* * * *

Grounding Distribution Circuits—Please publish the following to be answered by some of your readers: In our plant we have a 3-wire system for lights, of which the neutral wire is grounded at the transformer. The National Code reads: "If a system is grounded at the transformer it must also be grounded at each distribution box, or at intervals through the plant." We do not happen to have the grounds at intervals in the plant and that is where part of our trouble lies.

I was called to repair some lights in one of our departments with the complaint that some were very bright and others very dim. Upon arriving there I turned out all lights and took each one separately. Circuit No. 1 did not light; circuit No. 2 was burning about 220 volts, or twice normal; circuit No. 3 burned normal. Upon changing circuit No. 2 to normal, circuit No. 1 also burned normal. Can anyone explain this? What good is the ground at the transformer without other grounds at intervals throughout the plant? What harm could result should the permanent ground be removed?

St. Louis, Mo. E. H.

E. H. does not say whether or not his system is 110-220 volt with a grounded neutral, but I assume this to be the case. I think that his trouble with some lights burning too bright and others not bright enough is due to a blown neutral fuse somewhere on the system or a loose connection or some other high resistance on the neutral conductor. This neutral conductor should not be fused. This does not mean that the two-wire circuits feeding from cutouts to lamps should not have both sides fused, for they should, but the three-wire mains should not have a fused neutral.

I think that E. H. is mistaken when he says that the National Electrical Code says that the neutral conductor must be grounded at the transformer and at intervals throughout the plant. Rule 15A of the Code says that the neutral conductor must be grounded at the transformer or at each individual service. In this city we prefer to ground at each service rather than to depend on one ground at the transformer.

These grounds are placed upon the secondary system to protect the inside wiring from high voltage coming into the buildings from crosses on the outside wires or from transformer breakdown. One ground in such a case is as good as several as long as it is a good one. More than one ground is preferable as some of them may become disconnected.

From the above statements it can be seen that one ground at the transformer will give good protection as long as it is in good condition regardless of whether or not there are other grounds on the system. The only harm that would result from the ground being removed from the transformer would be that the protection from high voltage would be gone. All the grounds mentioned above are on the service wires outside the main switch and cutout. All wires inside the main switch and cutout should be free from grounds.

PERCY A. BLAISDELL.

Everett, Mass.

* * * *

Rewinding Motor for Four Speeds—We have a 5-hp., 1800 r.p.m., 220-volt, 3-phase, 60-cycle induction motor which has 48 slots in stator and is wound with 24 coils made of 13 turns of No. 15 wire. This motor is now connected single star. There is room in the stator for another winding due to there now being only one coil in each slot. There are 55 bars in the rotor. Short circuiting rings are ½ in. square, laminations 3¾ in. wide.

We would like to know if it is possible to rewind this motor with two sets of winding and secure four speeds: 600, 900, 1200 and 1800. The horsepower required at slow speed is about one.

Logan, W. Va. B. S.

The induction motor referred to by B. S. can be rewound for four speeds, as follows:

Basing all calculations on the existing 5 hp., 220-volt, 1800 r. p. m. data, which is 48 slots and 24 coils (basket winding or one coil per slot) 13 turns of one No. 15 wire. For the old winding B. S. does not give the number of wires in parallel, nor coil pitch. However, the coil pitch for a basket winding and 4-poles would be either 1 and 10 or 1 and 12, assuming one wire in hand. If there are more wires in parallel, B. S. can use the same number of wires, but of the size given in my final figures. The present winding is connected series star.

We will first design the motor for a constant horsepower at all speeds, using two windings, one for 4 and 8 poles, 1800 and 900 r. p. m., and the second winding for 6 and 12 poles, 1200 and 600 r. p. m.

When winding the stator put the 4-pole winding on first, in the bottom of the slots, and the 6-pole winding on top and connect each winding on opposite sides. That is, the 4-pole on the right hand side and the 6-pole on the left hand, or vice versa.

To obtain 4 and 8 poles or 6 and 12 poles from one winding, we will have to resort to a salient and consequent pole connection. Also to get a constant horsepower, a series-delta connection will be used for the high speed, 1800 and 1200 r. p. m. 4 and 6 salient pole windings, and a two-parallel, star connection for each low speed 900 and 600 r. p. m. 8 and 12-pole winding. The way this connection keeps the hp. constant will be explained later. A two-layer (diamond mush coil) lap winding will be used for each winding.

The first step is to change the present 1800 r. p. m. winding for 220 volt, series-delta. 24 coils ÷ 3 equals 8 coils per phase. 13 turns × 8 coils equals 104 turns per phase. Then for a series-star connection the voltage per phase equals 220÷1.73 equals 127 volts. Assuming a 1 and 12 pitch the chord factor is .99144, or the sin of 165 deg.÷2. Then the voltage per turn for full pitch will be (127×1.009) divided by 104 equals 1.23 volts per turn.

For a 1 and 10 pitch the chord factor is .92388, and full pitch voltage per turn equals (127×1.076) divided by 104 equals 1.3 volts per turn. For the base we will take the average of these two values of volts per turn, or (1.23+1.3) divided by 2 equals 1.26 volts per turn.

The turns per phase for a full pitch series-delta connection equals 2 equals 1.26 volts per turn.

The full load ampere rating of a 5 hp., three-phase, 220-volt induction motor is approximately 15 amp., and for a series-star connection the amperes per phase are equal to the line rating. Then the circ. mils per ampere equals 3256 divided by 15 equals 217, where 3256 is the area of one No. 15 wire. Then for a series-delta connection the amperes per phase equals ampere per line divided by 1.73 or 15÷1.73 equals 8.61. The area of the wire equals 217×8.61 equals 1868.37 circ. mils. One No. 18 has 1624 circ. mils and one No. 17 has 2048 circ. mils. The No. 17 should be used if there is sufficient slot room.

Now on all multi-speed induction motors the coil pitch is made one hundred per cent for the lowest speed of each winding. Then for the 4 and 8-pole winding the coil pitch is 48÷8 equals 6, or 1 and 7, and for the

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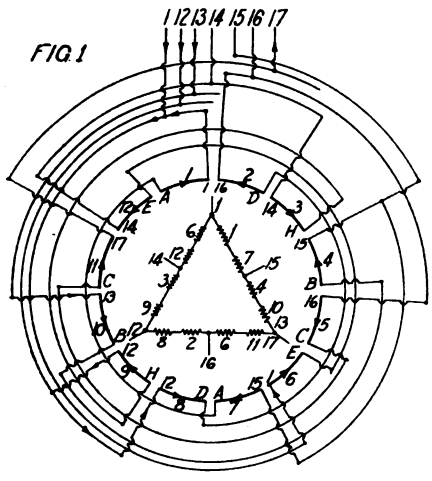


Fig. 1—Diagram for four-speed, four-pole series-delta connection.

Connect lead 1 to *A* line, lead 12 to *B* line, leads 13 and 17 to *C* line. Leads 14, 15, and 16 are left open. The coil pitch is 1 and 10 and the coils are wound with 13 turns of one No. 17 wire. There are 12 groups of 6 coils per group.

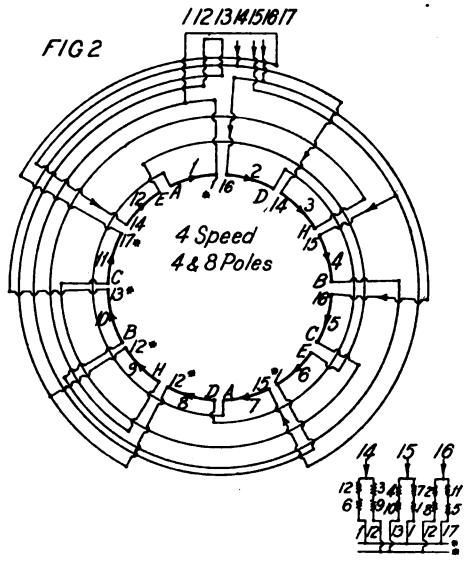


Fig. 2—Diagram for four-speed, 4- and 8-pole motor with parallel star (consequent poles) connection.

For four-speed, eight-poles, connect lead 14 to *A* line, lead 15 to *B* line, and lead 16 to *C* line; also connect together leads 12 and 13, and 1 and 17.

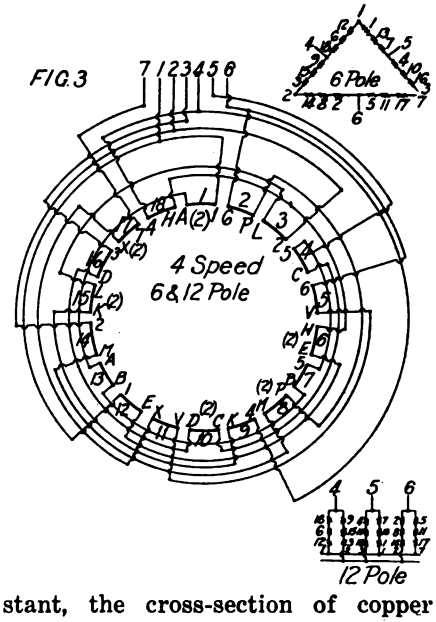


Fig. 3—Diagram for four-speed, 6- and 12-pole motor.

For six-pole, 1200 r. p. m. series-delta connection, connect lead 1 to *A* line, lead 2 to *B* line and leads 3 and 7 to *C* line. Leads 4, 5, and 6 are left open. For 12 poles 600 r. p. m., parallel-star (consequent poles) connect lead 4 to *A* line, lead 5 to *B* line, lead 6 to *C* line; also connect leads 1 and 7 and 2 and 3 together. Note that lead 1 is connected to lead 4 on 4- and 8-pole winding or 14 leads can be brought out and this connection made outside at controller or outside of motor. The coil pitch is 1 and 7 and the coils are wound with 20 turns of one No. 16 wire. There are 18 groups of 4 coils per group.

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6 and 12-pole, 48÷12 equals 4, or 1 and 5.

Then for the four-pole winding the coil pitch is reduced and the chord factor is .707. The full 4-pole pitch is 1 and 13, or 12 slots, which equals 180 deg. With a span of 6 slots the electrical angle equals 15×6 equals 90 deg., or 50 per cent pitch. The sin of 90 deg.÷2 equals .707.

The turn for the series-delta winding will have to be increased to compensate for the reduced chord factor, for with 174 turns the voltage would be 220×.707 equals 155.54 volts. The new turns are obtained from the proportion 220÷155 equals x÷174 or x equals (220×174) divided by 155. This equals 246 turns per phase. Then as there will be 48 coils, 48÷3 equals 16 coils per phase. The turns per coil equals 246÷16 equals 15. The 4 and 8-pole winding, therefore, will be 48 coils of 15 turns of one No. 17 wire with coil pitch 1 and 7. By connecting as per Fig. 1, this is the series-delta connection. Note that the delta is opened at one point; this is to prevent circulating currents, as only one winding is in use at one time, and if the winding not in use formed a closed circuit it would act as the secondary of a transformer. To overcome this both windings are opened as indicated.

Fig. 2 shows how the eight poles are obtained. Note that the direction of the current as indicated by the arrows is reversed in groups 2, 4, 6, 8, 10 and 12, and all arrows point the same, thus forming poles between each group. Fig. 2 is a two-parallel star connection.

The way these two connections tend to keep the horsepower constant is as follows: The series-delta connection is good for 220 volts, 15 amp., 1800 r. p. m. 5 hp. The wire in each phase will carry 8.61 amp.

Changing to parallel-star, the voltage per phase is 110 volts, or the line voltage should be 110×1.73 equals 190 volts. Then if 220 volts are applied, it will be 16 per cent over voltage, and as each leg of the star circuit is good for 8.61 amp., the line current could be 2×8.61 equals 17.22 amp., which is an increase of 14.8 per cent. Then the net result is to reduce the total turns and increase the current-carrying capacity, both of which will increase the maximum torque and tend to keep the horsepower constant.

The 6 and 12-pole winding is figured on a percentage basis of the 4-pole winding or 6-pole turns per coils. The following proportion is used: 1800÷1200 equals T÷15. Or T equals (1800×15) divided by 1200, equals 22.5 or 22 turns will do. As the horsepower is to remain constant, the cross-section of copper should also be *increased* in the same proportion, or the circ. mils equals 1800÷1200 equals A÷2048. A then equals (1800×2048) divided by 1200 equals 3072, or one No. 16 will do. The 6 and 12-pole winding will consist of 48 coils, 22 turns, of one No. 16 wire per coil, with pitch 1 and 5. There will be 18 groups, 12 groups of three coils in series and six groups of two coils in series. The location of the six two-coil groups should be as shown in Fig. 3, which gives the connection for the 6 and 12 poles.

From the above it follows each slot will have 2×15 equals 30 No. 17 wires, and 2×22 equals 44 No. 16 wires, which appears out of the question, as a multi-speed induction motor of constant horsepower will be about 150 per cent larger than a corresponding single-speed motor of the same horsepower at the highest speed.

But as B. S. states only one horsepower would be required at the lowest speed, or for 1200 and 600 r. p. m., then the size of wire for this winding can be reduced in the following ratio: 5÷1 equals 2582÷x or x equals 2582÷5 equals 516.2. By using the full value found before 3072÷5 equals 614.4, or one No. 22.

If the original 4-pole motor was designed for constant duty and the redesigned winding is to be used for intermittent duty, the size of wire could be reduced one number, that is, 18 or 19, 23 or 24.

From the above B. S. can determine whether the motor in question can be rewound. The rotor will be O. K. for each speed, hence no change is required.

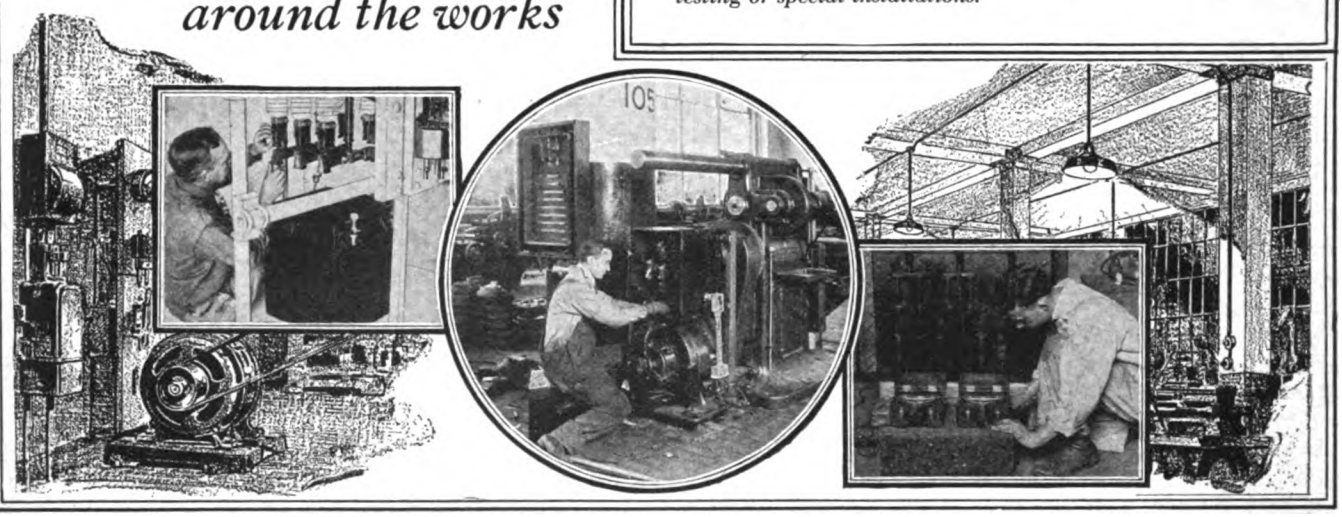
A. C. ROE.

Detroit, Mich.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

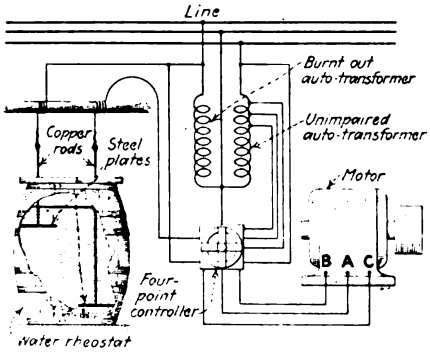


Improvised Starter for a Three-Phase Induction Motor Prevented a Shut-Down

RECENTLY one of the auto-transformers in the starting compensator of a large three-phase induction motor became disabled. As the motor could not be spared pending the arrival and installation of a new autotransformer, the engineer devised the temporary starting apparatus shown in the accompanying sketch. He filled an empty oil-height with water, and suspended height with water, and suspended therein two ½-in. steel plates, each about 10 in. square. A quantity of salt dissolved in the water increased its electrical conductivity.

The compensator was designed for operation at four different voltages. As the motor would start on the second point of the controller, it was necessary to fix the distance between the steel plates immersed in the salt water so as to give the allowable voltage at this point. To find this point the three leads were disconnected from the motor and a voltmeter was connected across the terminals *A* and *B*, thus spanning the autotransformer which was still operating. The switch was then thrown in the starting position and the indication of the voltmeter noted. The voltmeter was next connected across the terminals *A* and *C* and, with the switch still in the starting position, the distance between the steel plates in the water-rheostat was adjusted so as to give the same reading as before. The motor was then reconnected and made ready to start. When the motor attained the speed permitted by the diminished voltage allowed by the improvised rheostat, the engineer would throw on full voltage with the controller.

St. Louis, Mo. A. J. DIXON



Water rheostat used as half of starting compensator when it was necessary to provide a temporary expedient to prevent a shut-down.

Tinfoil Can Be Used for Cleaning Nameplates

OFTEN it is necessary to clean off the nameplate of a motor, generator or other device in order to read the data. Unless the equipment is well cared for, the nameplates tarnish and become heavily coated with grease and dirt so that it is impossible to read the figures without first cleaning the plates. Sandpaper, emery cloth, and other abrasive agents will remove the accumulated dirt but always scratch the metal badly. On the other hand, a can of some metal polish which will clean without scratching is not always available, nor is it convenient to carry such material around.

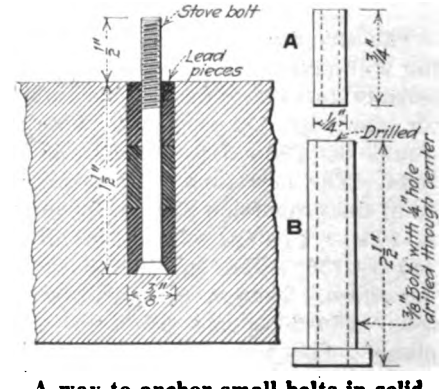
After trying various methods of cleaning nameplates I have found that a wad of tinfoil such as is used for wrapping friction tape can be used with good results. The more the foil is crinkled the better it works. It is always available, does not cost anything, will not scratch or mar the plate, and is clean.

Electrician, Patchogue Electric Light Co., Patchogue, N. Y. HENRY MULFORD.

Stove Bolts and Pieces of Lead Pipe Used for Anchor Bolts

FOR anchoring conduit, switches, cutout and junction boxes to brick and concrete walls, stove bolts and pieces of lead pipe can be effectively used, as shown in the accompanying illustrations, when expansion bolts are not available.

A ⅜-in. hole is drilled in the wall 1½ in. deep and a 2-in. stove bolt inserted. Pieces of ¼-in. lead pipe are then cut ¾ in. long, as shown at *A*, inserted over the stove bolt



A way to anchor small bolts in solid walls.

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and driven into the hole with the aid of the tool shown at *B*. Enough of these pieces are used to fill the hole completely. The stove bolt will then be solid and remain so.

Greenville, S. C. E. R. HOWARD.

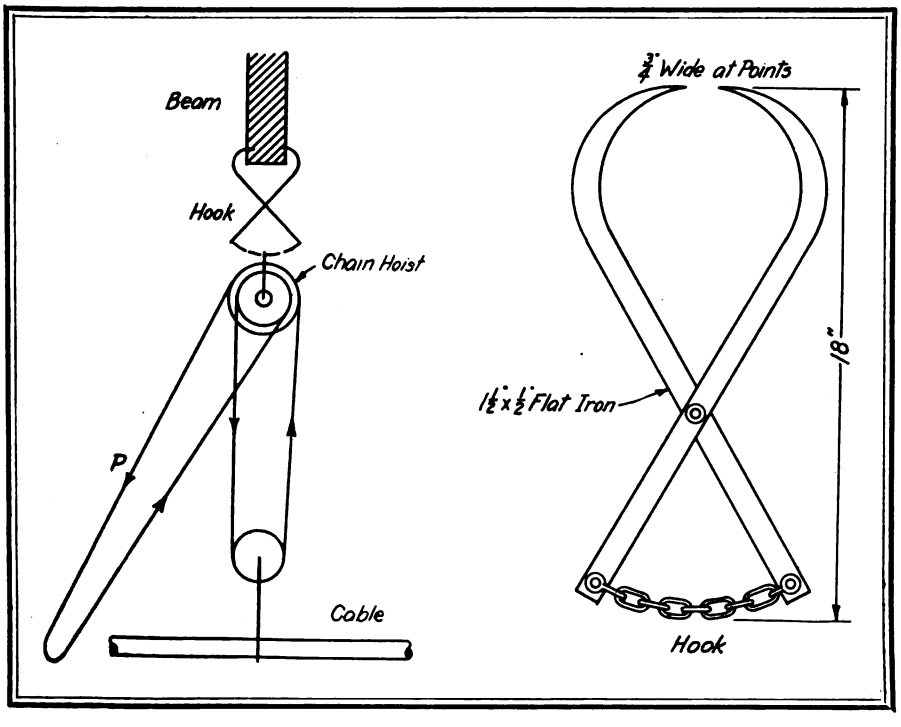
Simple Hook Facilitates Overhead Installation of Cable in Factory Building

BUILDING alterations recently made it necessary to install in a temporary location 1,000 ft. of 2,000,000 circ. mil. lead-covered cable. Inasmuch as this cable weighs approximately 10½ lbs. per foot, and had to be mounted at a height of 18 ft., besides passing through three walls and one floor, we had to devise some easy method of raising the cable and supporting it until it could be placed in the hangers. The building in which the cable was to be installed has wood columns and beams, and it was finally decided to make a hook or tongs, somewhat like an ice tongs, which could be suspended from the wood beams. As will be seen from the accompanying illustration, which also shows the method of using it, this hook was made of 1½-in. by ½-in. flat iron, forged to a width of ¾ in. at the points. The points were ground sharp, but care was taken not to grind the under side of the points, as that would tend to let the hook slip. The length of the hook is 18 in., and the lower ends are connected by a short length of chain secured by bolts.

When the hook is slipped over a beam and a pull exerted on the chain the sharp points are forced into the wood and keep the hook from slipping. For installing the cable two hooks were used, with a chain hoist suspended from the chain of each hook. The hooks were placed ahead of a portable scaffold from which the installers fastened the cable to the hangers. By the use of these hooks seven men were able to install the entire length of cable, weighing over five tons, in 9½ hours.

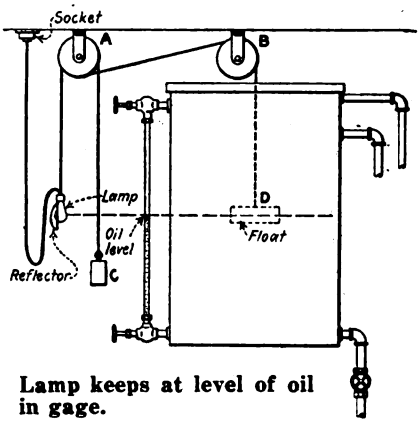
La Salle, Ill. W. L. RAMBOUSEK.

This hook grips the wood beam and supports the chain hoist.



Moving Lamp Helps in Reading Glass Oil Gage

AS IT was difficult to see the level of the oil in a glass gage, the engineer in charge of a dynamo and engine plant arranged a lamp so that it moves up and down with the level of the oil. Two wooden pulleys, *A* and *B*, each about 10 in. in diameter, were suspended in hangers fastened to the ceiling as shown in the sketch. One end of a 3/16-in. cotton cord was attached to a 4-lb. weight, *C*, and the cord was wound differentially around the two pulleys —three turns being taken on each. The other end of the cord was then secured to a 5-lb. copper float, *D*. One end of another 3/16-in. cord was fastened with a nail to the rim of pulley *A* alongside the first cord. Two turns were wound around the pulley with this second cord in the opposite direction to the winding of the first cord. An incandescent lamp, with a reflector attached, was then suspended from the free end of the second cord.



Lamp keeps at level of oil in gage.

With this arrangement the lamp rises and falls simultaneously with the rise and fall of the float in the tank. Thus the light of the lamp is constantly reflected on the glass at the level of the oil.

St. Louis, Mo. A. J. DIXON.

Where Lead-Covered Conductors Are Necessary in Industrial Plants

THE importance of providing lead coverings for insulated electrical conductors installed in underground conduit or other moist locations in industrial plants is not so widely recognized as it should be. Where this practice is not followed, much trouble results, often involving interruptions of service. Recently several instances of trouble showed up in industrial plants where rubber-insulated wires or cables were installed in underground conduit. The cases of trouble were not confined to outdoor locations, but were found inside of buildings, as for instance, in a steel rolling mill where the conduit for control wires passed under the rolling machinery. Moisture from the spray water used to cool the rolls seeped through the floor and found its way into the conduit. As a result, the braided, rubber-insulated wires gave considerable trouble and had to be replaced every eighteen months. Another rolling mill which had a similar problem finally used a lead-covered cable as a remedy.

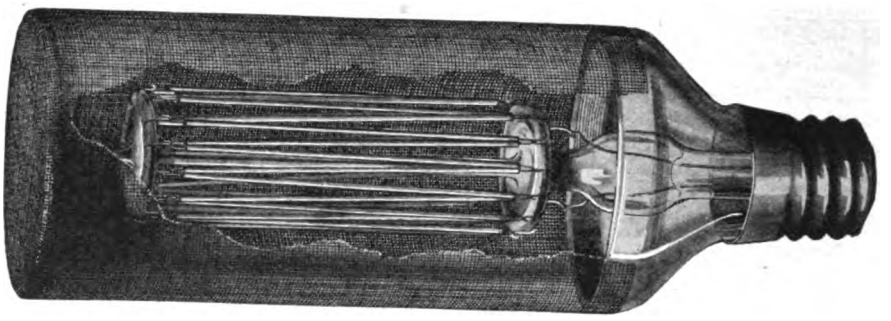
Another instance was in a plant where the electrical conductors were

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in underground fiber conduit laid between buildings in concrete. Although every effort had been made to exclude ground moisture, nevertheless the insulation failed. Even if it were possible to construct and maintain underground conduits in such a way as to exclude ground moisture, it is absolutely impossible to prevent the condensation of moisture from the air in them. Also, there can be no assurance that ground water will be permanently excluded, because the concrete is liable to crack from many causes, such as heaving of the ground on account of frost, settling, passage of heavy loads and so on. A similar deterioration of impregnated braids and rubber insulation also occurs with the high-grade wires used for railroad signaling where the small wooden troughs, known as "trunking," in which they are laid, is placed underground as, for instance, when crossing under tracks. In some particularly bad locations these wires have to be replaced every year. The wiring of packing houses is another instance of the absolute necessity of using lead-covered wires and cables in damp locations.

On the other hand, an extensive survey of brass rolling mills, shipyards and other industries shows that the practice of installing cables with lead covering for underground distribution is well recognized and applied by the most up-to-date engineers. Some large plants have several miles of such cable and although the first cost is higher than for braided cables, the longer life. insignificant maintenance and freedom from interruptions of service reduce the annual charges to the lowest attainable figure. This practice is, moreover, in accordance with the standards of the National Board of Fire Underwriters as well as of the American Institute of Electrical Engineers.

The "National Electrical Code" requires that all wires in damp locations be lead covered. In one factory building, for example, rubber-insulated, lead-covered cables were used between the switchboard in the cellar and the panel on the first floor because the cellar did not extend under part of the building where the ducts were run. Experience has shown that conduits in the ground are cool enough to cause condensation of the warm air from the building which is bound to circulate through them.



A special lamp for burning combustible elements out of gaseous mixtures.

Suitable resistance is used to keep the filaments below 700 deg. C., which is too low a temperature to explode the mixture, and a special catalyst is employed to burn out the combustible gases. The wire gauze acts on the principle of the Davy safety lamp.

The Marine Code of the Institute of Electrical Engineers also requires lead-covered wire below the water line of ships because of the condensation which takes place on the cool surface of the steel work to which it is attached. The Navy Department even goes so far as to have all wire on warships lead-covered.

One consideration, however, which, in addition to electrolysis, must be taken into account in the use of lead-covered cables, is that certain soils contain chemicals injurious to lead, particularly alkalis and acids from decaying vegetation. Slag and cinder fills or lime are likely to produce dangerous conditions, especially when used in concrete construction. To overcome bad soil conditions, some engineers place a few inches of loam or sand around cables buried directly in the earth and have met with remarkable success. Many instances are on record, however, where lead-sheathed cables in conduit lines constructed in ground consisting of cinder or slag fill have been in service for ten years or more and do not show any signs of deterioration. The secret of this success undoubtedly lies in good drainage of ducts and manholes.

The American Committee on Electrolysis, in collaboration with the Bureau of Standards and the Underground Systems Committee of the N. E. L. A., is now carrying on an extensive series of tests to show the action of various types of soils on lead sheaths. The results will be available to the public from time to time as they progress and should throw much light on this now rather obscure subject. F. A. WESTBROOK.

Field Engineer,
Habirshaw Electric Cable Co.,
New York City.

Burning Out Accumulations of Explosive Gas by a Special Lamp

THE accumulation of explosive gas mixtures in enclosed spaces is of frequent occurrence, and accidental ignition of these explosive mixtures has led to disastrous results in sewer systems, service tunnels and underground systems. The same problem presents itself as a result of gas mixtures which accumulate in closed vaults containing control apparatus, electrical or otherwise, in transformers and around similar apparatus.

The gases accumulating under these conditions may arise from a variety of causes. In general, however, they are essentially hydro-carbons (principally methane and related compounds) with occasional admixtures of hydrogen and carbon monoxide. In underground systems in streets there is some possibility of the accumulation of gasoline vapors or of illuminating gas from adjoining mains or, in unusual cases, gases arising from the accidental destruction of the organic insulating materials commonly used. In systems where considerable quantities of lubricating oils are used, a slight accumulation of explosive vapors may arise from these materials.

The danger of explosion can be eliminated by continuously removing the explosive mixture by burning it up more rapidly than it can accumulate. To do this the gas must be oxidized at a temperature considerably below the explosion point, which can be done by the use of an oxidative catalyst finely distributed over a porous surface. A description of the principle of this operation, and some of the results attained follows:

A special lamp is made up as shown in the accompanying illustration, with a lamp base which may be screwed into any ordinary lamp socket to connect with a 110-volt circuit. The leads are brought in from this base in the standard fashion

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through a glass insulating member. A fine mesh wire screen, to prevent any flame which may form in the interior from striking through to the outside according to the well-known Davy principle, is attached to the glass bell which fits into the socket shown. As a matter of fact, the device is so designed that the possibility of formation of a flame in the interior may be neglected. Many experiments were made with the bare and unprotected filament, but the wire gauze is an additional security. The filament itself is the simplest form of a coil. In practice a number of designs of lamp, more suitable for special purposes, are used and consist either of a solid porous cylinder internally heated or of wires sheathed in porous tubes and arranged to form a hollow cylinder.

The essential feature in the whole device is the application of a catalyst to a porous surface of considerable area, and the control of the resistance of the whole system so that it normally operates at a safe and effective temperature. The temperature found to be most satisfactory for use in connection with a platinum catalyst is between 600 and 800 deg. C. The best temperature of operation depends somewhat on the catalyst used and the results have varied accordingly.

Throughout an extended series of tests with numerous gases and a variety of lamps, ignition of the most highly explosive vapors was never obtained. About 700 deg. C. is considered a safe temperature for the device as constructed. Some of the results obtained at various times, based on 5 cu. ft. of gas and using a lamp of the most effective type with a platinum catalyst, have been as follows:

Combustible Gas	Pct.	Air, Pct.	Percentage Burned Out
Pittsburgh Nat'l Gas..	8.6	91.4	43 in 24 min.
Rich Coal Gas.....	8.6	91.4	40 in 24 min.
Lean Coal Gas.....	10.0	90.0	57 in 24 min.
Hydrogen	10.0	90.0	56 in 10 min.

A surprising feature of these results is that the device functions even in a 10 or 15 per cent hydrogen-air mixture. This is probably the most severe test that could be made. The rate of consumption is considerably increased in this mixture, as may be noted. For mixtures of air and hydrogen (as found in submarines and the like) a type of lamp specially designed for this purpose is recommended.

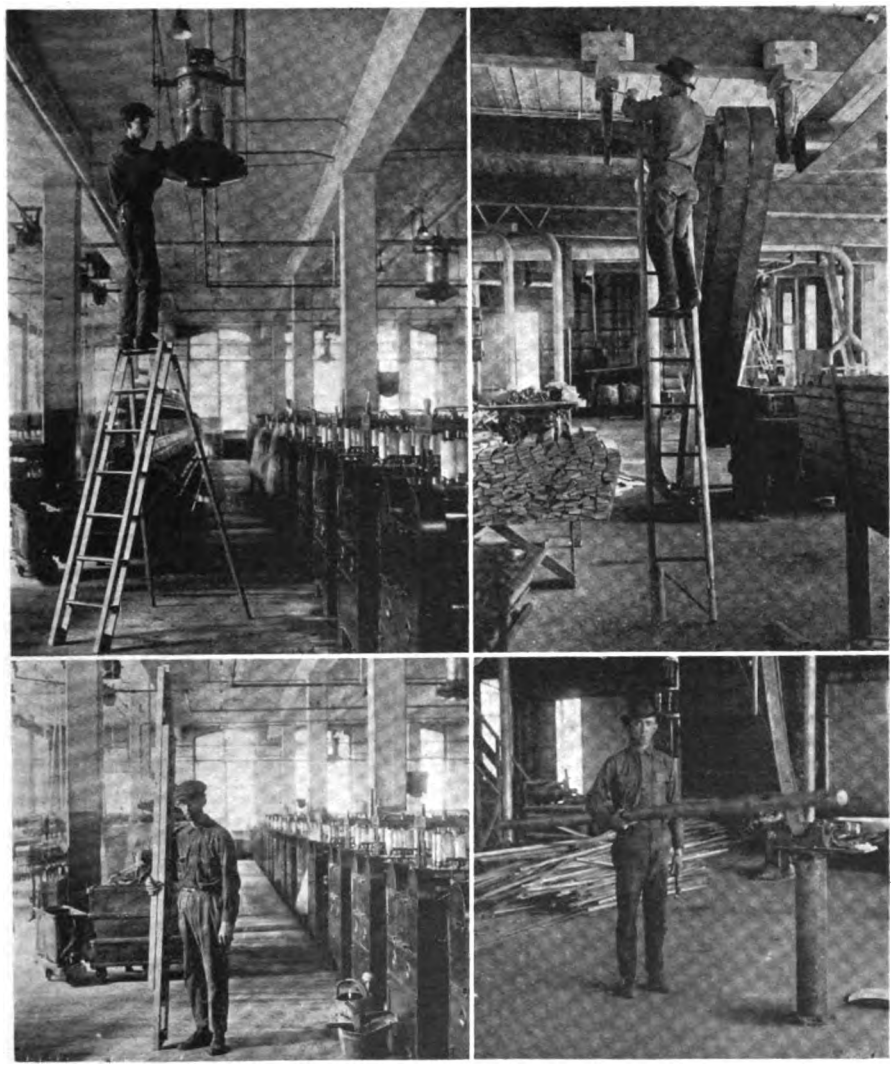
When actively funtioning in an explosive mixture, the temperature of the filament increases somewhat, due to the heat of reaction. This rise is readily discernible and the temperature drops again when the combustible gas is exhausted, giving a qualitative indication of the presence of explosive vapors. By the use of a thermocouple junction this indication may be made to be self-recording and capable of accurate measurement.

DR. H. C. P. WEBER.
Research Laboratory,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

Simplifying Maintenance Work by Using Folding Ladders

ALTHOUGH practically every man responsible for maintenance and operation would gladly eliminate the use of ladders the nature of the work is such that it is often necessary to use both step ladders and ordinary straight ladders. It is an advantage, however, to have these ladders as light and convenient as possible without in any way sacrificing strength. The four pictures in the accompanying illustration show both a step ladder and a straight ladder which are made not only light but to fold so that they can be conveniently carried from one place to another as the oilers, cleaners or other maintenance and repairmen go from one job to the next. These ladders, made by the Peerless Folding Ladder Company, Greenville, S. C., are shown both in actual use and folded for carrying. The straight ladder, as shown at the right, folds into a round pole; the step ladder, as shown at the left, folds into a convenient bundle for carrying.

G. E. F.
Chicago, Ill.

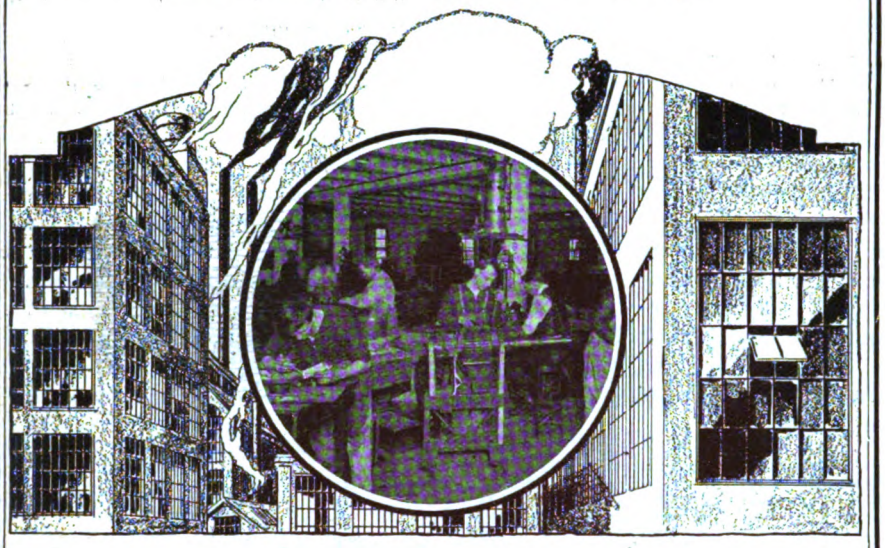


Two types of folding ladders which make it easy to carry them from one job to the next.

The folding step ladder as shown in the upper illustration at the left is rigid, when in use, strong, and has a wide footing for the step but in addition can be folded up, as shown in the illustration directly beneath it, so that it can more easily be carried from place to place. Straight ladders, as shown in the upper and lower illustrations at the right are also folded into a bundle resembling a pole only a foot or two longer than the original ladder. With a light ladder, which is easy to carry and erect, oilers are less likely to shirk oiling in out-of-the-way places.

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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Motor Changed from Two-Phase to Three-Phase by Springing Coils to Different Pitch

RECENTLY a 400-volt two-phase motor came into the shop to be changed for operation on 440 volts three-phase. In making the change it was found that the old coils could be used after reinsulating them and springing them to span a smaller number of slots. This meant that the expense of new copper was saved. The motor was of the squirrel-cage type rated at 40-hp., two-phase, 400 volts, six poles, 480 r.p.m., 25 cycles. It had 144 slots and coils. Each coil had three turns of one 1/16-in. by ½-in. copper strap, and a pitch of 1 and 25. There were twelve groups and twelve coils in series per group.

Using the small coils and pitch, the three-phase delta voltage would be $400\times2\div0.90\div3\times0.955$. The value 0.90 is the distribution factor for a two-phase motor. Taking both phases the total voltage generated is $400\div0.90\times2$. Dividing by 3, we get the numerical sum of all voltages in one phase of a three-phase motor. Here, again, we must apply the distribution factor if the machine is operated as a three-phase machine. The distribution factor for a three-phase machine is 0.955 and therefore $400\div0.90\times2\div3\times0.955=282.94$ volts is the voltage of the machine connected in series-delta. If the machine is connected series-star, the line voltage will be 1.73×282.94, or 490 volts, provided the chord factor is the same as it was before. This voltage, 490, is 11.36 per cent too high for 440-volt operation. Therefore we must reduce it by decreasing the chord factor.

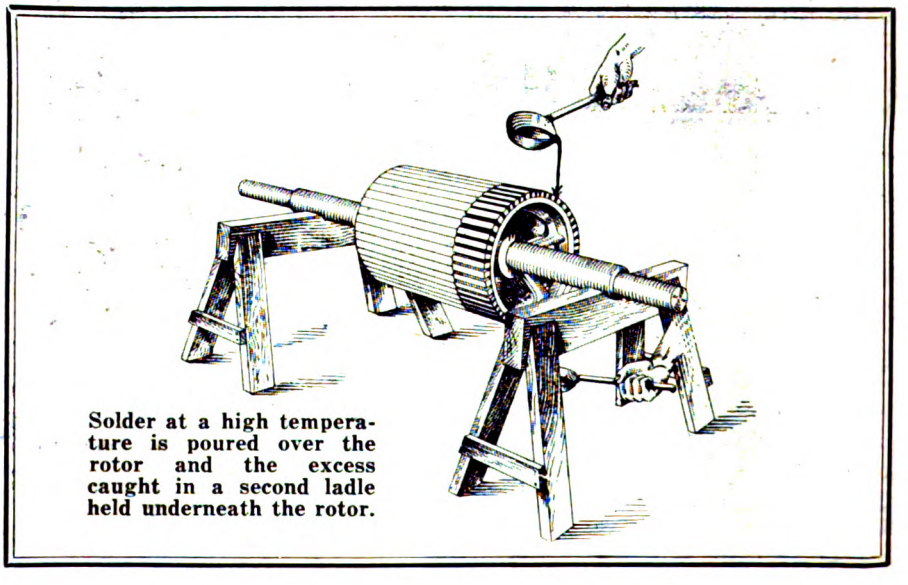
The chord factor of the two-phase winding was figured as follows: Full pitch was 144 (slots) ÷ 6 (poles) which equals 24 slots, or pitch of 1 and 25. The actual pitch was 1 and 23, or 22 slots. Therefore the chord factor equals the sine of ½ ($180\div24\times22$) degrees, or sine 82 deg. 30 min., which equals 0.99144. The full pitch voltage would consequently be $490\div0.99144=495$ volts. But the voltage should be 440 therefore it was necessary to reduce the chord factor to a value that would give 440 volts. This chord factor is $440\div495=0.89$. For a coil pitch of 0.89 it must be true that 0.89 equals the sine of ½ the angle spanned by the coil. The angle whose sine is 0.89 is 62 deg. 52 min. Therefore the coil spans 2×62 deg. 52 min. or 125 deg. 44 min. But full pitch equals 180 deg. therefore the required pitch $= 24\div180\times125\ (60\div40)=16.7$ This means the coil must span 17 slots or have a pitch of 1 and 18. The exact chord factor is sine ½ $(180\div24\times17)=0.89687$ which is within 1 per cent of 0.89.

Consequently the coils were sprung to fit the pitch and re-insulated. The number of phase coils equals twice the number of groups and there were eighteen groups of eight coils each. The number of groups equals the number of poles multiplied by the number of phases. The motor was connected in series-star. Since the change it has operated satisfactorily in every respect.

A. C. ROE.
Detroit, Mich.

How to Solder Large Rotor Without Use of Soldering Iron

IT IS practically impossible to solder very large rotors with a soldering iron. Such soldering can, however, be done in a small shop by the use of two ladles, as shown in the accompanying drawing. For this purpose the solder is made very hot and then poured from one ladle over the ends of the rotor bars, while the other ladle is held underneath to catch what runs off. When first starting this operation with a cold rotor, the solder will pile up in heaps and not join the bars to the end ring. However, as the pouring is continued, the bars become hot and the excess



Solder at a high temperature is poured over the rotor and the excess caught in a second ladle held underneath the rotor.

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solder runs off into the lower ladle, while the joints will be completely filled.

The main point to remember when using solder in this way is to have it at a high temperature. If the solder is not hot enough, it is hard to do a good job. J. P. COLLOPY.

Owner and Manager,
Motor Repair Shop,
Fort Collins, Colo.

Handy Fuse Tester Made From Pocket Flashlight

THE ACCOMPANYING diagram illustrates a pocket flashlight converted into a fuse tester for the maintenance man's or factory electrician's kit. It can be carried in the pocket and the alteration does not interfere with its operation as a flashlight or the action of the push-button switch.

The device is made of a small, flat, nickel-plated pocket flash-light as shown in the accompanying drawing. To make this a ¼-in. hole is drilled in the metal case on the center of one side, about ¼ in. from the bottom rim, as indicated. Two flat-head 6-32 screws ½ in. long are soldered to the case in line with the ¼-in. hole and about 1 in. apart as shown. Next a piece of 1/16-in. brass, 1⅜-in. square, is cut with a circular notch as shown. Two ¼-in. holes are then drilled in this brass an inch apart to fit the two screws soldered on the case. Two ⅛-in. and one ¼-in. holes are drilled in a piece of fiber ⅜ in. by ⅜ in. by 1⅜ in. These holes are spaced to fit over the two screws and opening as shown at *A* in the accompanying sketch.

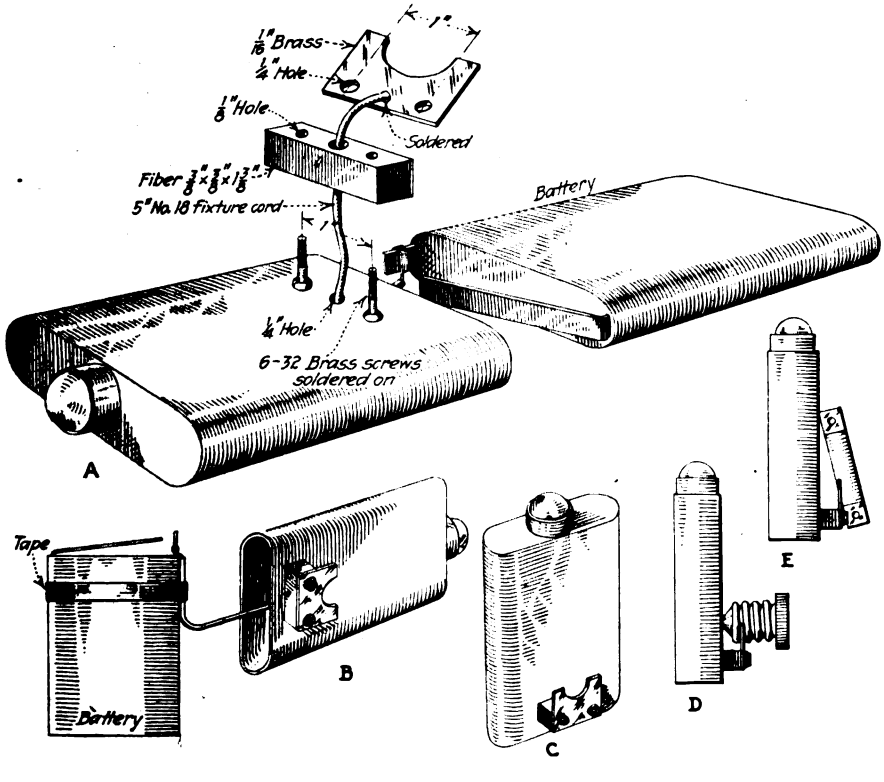
One end of a piece of No. 18 fixture wire about 5 in. long is looped around one of the battery terminals as shown at *B*. The insulation of the wire is retained close up to this loop which is slipped over the short terminal of the battery and the device is ready for assembling. Before assembling it is good practice to file off sharp edges on the ¼-in. hole in the case to prevent cutting the insulation on the fixture wire.

The testing device is assembled as follows: After putting the loop over the battery terminal, pass the other end of the wire through the hole in the case from the inside toward the outside, through the middle of the fiber block and solder it to the brass piece as shown at *A*. Next the fiber and then the brass piece are slipped over the screws, two fiber washers are added and tightened by two 6-32 nuts. The fiber washers fit into and over the ¼-in. opening in the brass plate and are used to insulate the screws and the nuts. After the nuts are screwed tightly the protruding ends of the screws are cut off and the rough edges filed smooth. The battery is then wrapped with one thickness of friction tape, as in *B*, to keep the fixture wire in place as well as to insure a good connection and to prevent the loop from interfering with the button switch.

The battery is then inserted in the usual way. The method of testing a plug fuse is shown at *D*, and the method of testing a cartridge fuse at *E*. If the fuse is good, the lamp lights. Care must be taken when assembling that the screws on the case do not come in contact with the brass piece. Also, it cannot be carried in the pocket or tool box with loose pieces of metal which might accidentally close the circuit and thus drain the battery.

Tuckahoe, N. Y. J. E. MCCARTHY.

Cartridge or plug fuses are easily tested by this simple device which can be made from a flashlight and carried in the pocket or tool kit.



Rebuilding Rotor End-Rings to Reduce Trouble

I SHOULD like to make a comment on Mr. Tillman's method for rebuilding rotor end-rings that appeared on page 61 of the January issue. I have used his method but I have welded the rotor bars to the new end-rings instead of soldering them and I have had absolutely no trouble with motors after repairing them in this way. The slot insulation is, of course, destroyed by welding them but in the ordinary induction motor this makes no difference in the operation and the chance of loose rotor bars is entirely eliminated. I can furnish additional details of the welding job if desired.

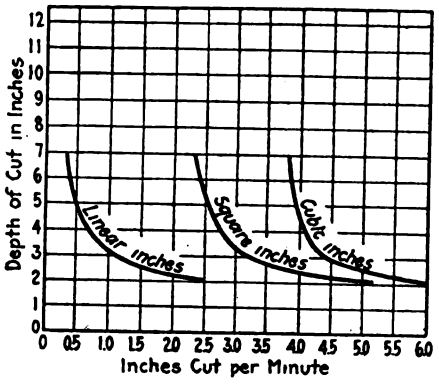
I shall take this opportunity to wish INDUSTRIAL ENGINEER the greatest success as it is filling a long-felt want. D. A. BLODGETT

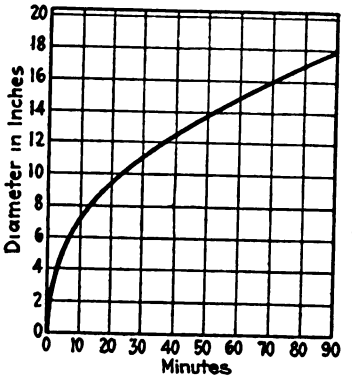
Chevrolet Motor Co.,
Flint, Mich.

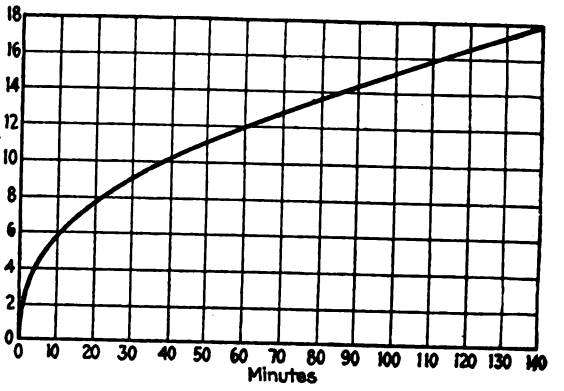
A. C. Fans Burn Out When Six Blades Are Substituted for Four

A NUMBER of six-blade induction-type fans were received in the shop for repairs during last season. Inspection revealed that in a number of cases the field winding and the series transformer in the base of the fan had been heated to such an extent that the insulation on the wires and around the coils was charred, and both windings were short-circuited. As the heating was generally distributed, the trouble was blamed on overload. This had

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These three curves show the time required to cut cast-iron pieces of varying cross-section.

This set of curves may be used in estimating the time required to do various types of cutting in cast iron. For making these tests a current of 600 amp. was used. Only the actual cutting time, however, is recorded here and allowance must be made for conditions which would retard the preparation or progress of the work.

been caused by substituting six-blade fans for the four-blade fans with which they were originally equipped.

When these fans were received in the damaged condition the style and serial numbers were checked and these proved that in each case the fans were originally of four-blade construction. By consulting the owners of the fans it was found that the following were the reasons for making such changes: (1) The owner wanted a greater volume of air, so he substituted six for four blades; (2) the original four blades were out of balance and could not be straightened. This was during a hot period and the owner could not get a set of four blades; so he took what he could get, which was six blades. The last example was from a dealer, who stated that when a call was received for a six-blade fan, the set of four blades was removed from a four-blade motor and the six-blade set substituted. This dealer had been substituting six blades for four in direct-current fans without any ill effects. These were all series motors and the substitution of six blades for four blades increases the load and slows down the fan, but the windings usually do not get warm enough to burn out.

With the induction type of fan the case is different. It is general practice to wind the stator of six-blade fans for six poles and the stator of four-blade fans for four poles. Hence the speed of each type is fixed. Furthermore the motor windings are of the single split-phase type and the load must be kept well within the pull-out torque of the motor. The synchronous speed of the four-pole motor is 1800 r.p.m. The six-blade fan is made to run at 1200 r.p.m. Therefore, if it is put on the four-pole motor its speed will be increased 50 per cent. The power required to turn the fan varies as the cube of the speed and, therefore, the four-pole motor would be working at a very great overload with a six-blade fan.

A. C. ROE.

Detroit, Mich.

Speed of Cutting Cast Iron of Various Thickness by Electric Arc

THE PROCESS of arc cutting is purely a melting process, the heat energy of the arc terminal being directed along the line where the cut is desired. In special cases metallic electrodes, heavily wrapped with asbestos yarn and using current values higher than normal, have been used for cutting after the electrodes are first dipped in water. This forms steam and blows the molten metal away. This method, however, is expensive and has been used to a limited extent by the British Admiralty for cutting deep, small diameter holes in armor plate. For general cutting work graphite or carbon electrodes are used with current values of 300 to 1,000 amperes, depending upon the nature of the work and the cutting speed desired.

Foundries make use of arc-welding equipment for repairing defective castings and use the same apparatus for cutting off risers and burrs from their castings. In one instance a 3-in. by 9-in. neck on a riser from a large grey-iron casting was cut through in 5 min., when using 800 amp. The riser was then cut through the main portion (8-in. by 8-in.) in 17 min., still using 800 amp. Labor at 60c an hour and electric power at 2c a kw.-hr., for the motor-generator, gives a cost of 15c for cutting the neck and 52c for cutting the body of the riser. The results of a number of experiments show the rate or speed that castings may be cut by the electric arc as given in the three accompanying charts. These show actual cutting time only and additional allowance must be made for any conditions out of the ordinary. The experiments are based on the use of 600 amp.

Where it is desirable to cut the material to accurate dimensions, it is necessary to lay out a guide line with white lumber crayon which the operator can follow with his arc. It is then possible to make a neat cut in ¼-, ⅜- or ½-in. steel plate at a high rate. For example, a piece of ¼-in. plate steel was cut at 75 ft. per hr. when using 450 amp.

For scrapping or rebuilding steel freight cars or similar plate fabrication the arc process is the cheapest method of removing rivets and cutting up steel plate material into pieces sufficiently small either to be charged directly into the cupola or to be handled for recutting in a shear. Because this plate material is generally covered with paint or rust current values of 400 to 600 amp. are frequently used and, in some instances, as much as 800 amp. Using this latter current value cuts have been made at an average rate of 75 ft. per hr. and an entire coal car cut up in 4 hrs. in pieces sufficiently small to be handled to the shears by four men at a total cost of $6.80 including labor and power for the motor-generator. When using 400 amp. an average operator will cut from 1,800 to 2,000 ⅝-in. rivets in a 10-hr. day although some operators will run as high as 2,600 to 3,100 rivets when the work is on a piece-rate basis.

Cutting with the arc is not limited to iron and steel but can be applied equally well to non-ferrous metals such as brass, bronze and copper. Some experiments made in cutting of copper by the electric arc were given on page 448, Sept., 1922, issue of the INDUSTRIAL ENGINEER. In fact, for cutting copper which cannot be cut mechanically the arc process has proved to be the cheapest.

A. M. CANDY.

Arc Welding Engineer,
Westinghouse Electric and Mfg. Co.,
East Pittsburgh, Pa.

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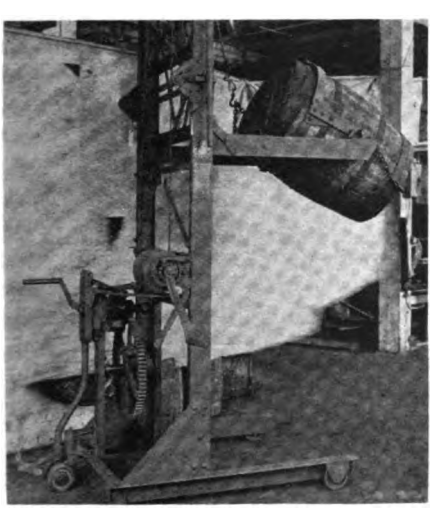


Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

How One Man Can Lift and Dump Heavy Barrels Without Danger of Loss or Injury

THE TASK of dumping barrels into vats or other containers is one of the difficult and awkward jobs around any plant. This is simplified at the plant of the Agar Provision Company, Chicago, Ill., by the use of the Economy portable elevator or tiering machine (Economy Engineering Company, Chicago, Ill.), shown in the accompanying illustration. Barrels are inconvenient to handle and when filled often weigh several hundred pounds, so that they would require two or more men to dump them conveniently. With sticky or slow running material the barrels must be held in position until it runs out or is scraped out. In addition there is always danger of the barrel slipping and causing a serious accident, resulting in injury to the men or the loss of the contents.

With the arrangement pictured here one man not only lifts the barrel but dumps it. When the machine platform is lowered the steel cradle-ring which holds the barrel rests upon the floor. The barrel is placed within the ring, the platform elevated slightly, and two short chains are hooked over the chime of the barrel. The platform is then elevated, by turning the crank, sufficiently high to dump. During the elevating operation the barrel is held in an upright position but suspended within the ring. As shown, the cradle rests on two pivots attached to the platform arms. By operating the hand winch, shown fastened to the frame work of the portable elevator, the barrel can be tipped to any angle and held there until the material has run out or is scraped out. The operator, when the barrel is tipped, can hold it in that position until the barrel is empty. When empty the barrel is lowered into its vertical position by releasing the hand winch and the platform lowered. This portable elevator may be moved from place to place, but as soon as the handle by which it is pulled is loosened it becomes stationary.



One man can lift and empty a barrel with this machine easier than could three by hand.

By removing the platform from a tiering machine and attaching to it the special steel cradle as shown in the illustration, one man can lift heavy barrels and hold them in position until the contents have emptied. This is not only safer for the men but eliminates the possibility of loss through a barrel slipping away from the man and spilling the contents.

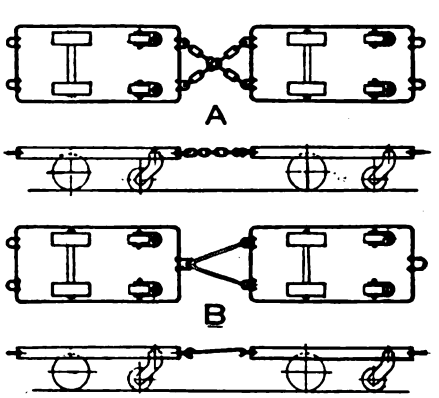
Preventing Excessive Wear From Trailers on Concrete Floors by Surfacing With Asphalt

WHERE electric trucks or tractors are installed for use over concrete floors, the steel-tired trailers frequently wear out the floor. This may be overcome if the floors are originally hardened when they are laid by using some form of hardener in the cement. In some cases of soft concrete floors the trailers have worn an inch or two into the soft concrete in the floor. This is difficult to repair due to the thin coat of concrete which can be laid.

One company which had considerable difficulty along this line laid a special cover of asphalt about 1½ in. thick over a section of floor which is subject to heavy traffic and which had worn quite badly. Two years later the asphalt showed but very little wear. Slightly more power is required for handling over the asphalt than is needed over sections of smooth concrete. This item, however, is small and is but little more than that necessary for worn spots.

Two Methods of Coupling Trailers Into a Train for Industrial Haulage

ONE OF the big problems incidental to the operation of trailers in connection with industrial tractors is to be sure that they will



Two methods of connecting trailers so that they will track properly.

Either of these simple types of connections may be easily applied to existing equipment so that it will track better when operated by industrial tractors. Type *B* it will be noted, is much more easily and quickly coupled than is Type *A* and it also tends to hold the trailers entirely apart, even though operated on down grade.

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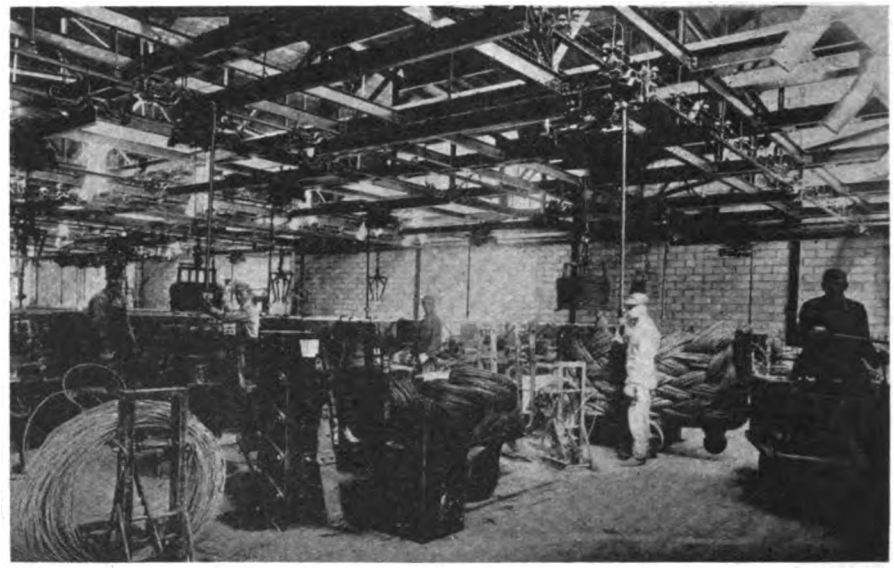
track properly. In this much depends upon getting the proper type of connections to join together the train of trailers. Two types of connections are shown in the accompanying illustration. In one case these are fastened together by chains while in the other a quick-coupling hook is used. Either of these methods is easily applied to trailers and may be used where difficulty has been found in this line.

Installing a Magnet Above a Belt Conveyor to Remove Stray Iron

MAGNETS have unusual uses which, although not as common and well-known, are just as interesting and important economically as the loading and unloading of iron or steel in quantities. In any application of a magnet, even the more powerful ones, it must be remembered, however, that it can only exert its power effectively through short distances—up to 12 or at the most about 15 in.

The accompanying illustration shows one such unusual use for a 40-in. Ohio magnet (The Ohio Electric and Controller Company, Cleveland, Ohio) wound with an energizing coil for continuous service. This is supported above a belt conveyor carrying silver ore at a mine at Fresnillo, Mex. The purpose of this installation is to extract stray or tramp iron or steel from the ore as it passes under the magnet. If such pieces are not taken out, they may break the crushing rolls and thus cause considerable delay and expense. Small magnets have been in use for this purpose in flour mills for many years but in late years many large magnets, such as that shown, are being used over belt conveyors carrying copper and lead ores, coal and other materials, to protect the crushing machinery from injury. In some instances this method is used to remove the iron from the material and so prevent its admixture in the product. In all such cases the magnet should be placed as close to the material as possible.

By the proper application of a magnet, scrap and stray iron may be easily removed from ore or other materials carried in a conveyor and so prevent the breaking of crushing machinery.



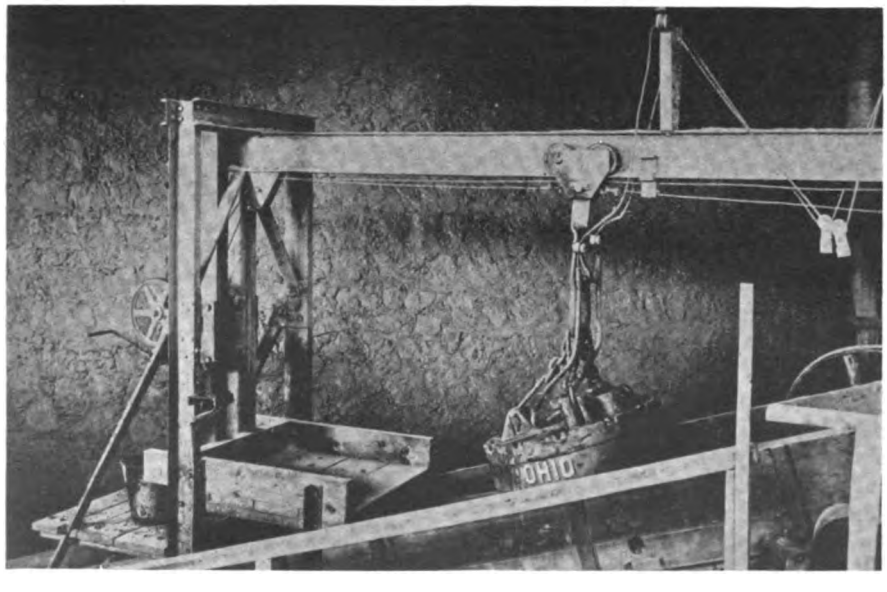
With this overhead hoist a small man can easily handle a 300-lb. bundle of wire.

It has been former practice in the steel mills to get men strong enough to handle these bundles. In times of labor shortage it is difficult to get such men. These hoists overcome much of this difficulty and enable a small man to do the work.

How Tramrail Hoists Enable Small Men to Do a Strong Man's Job

ON INDUSTRIAL operations where men are required to lift heavy weights or bundles during the manufacturing processes it usually pays to investigate the possibilities of using some of the various types of material-handling equipment for supplanting the heavy hand labor. One case where such equipment proves effective is in the steel industry. For example, it has always been the practice to use men strong enough to handle the bundles of wire from the wire drawing bench and also in and out of storage. This work requires a strong man, and as men get scarce it becomes more difficult to find men suitable for that operation.

Several steel mills have equipped their wire shops with electric tramrail hoists, as shown in the accompanying illustration. Here each electric hoist (The Cleveland Crane & Engineering Co., Wickliffe, Ohio), which is operated by push-button control, travels longitudinally on an I-beam. These I-beams in turn are so mounted that they have a cross travel. In this way one hoist can handle the work over a considerable area. Special care must be taken to see that the hoist does not bind either on the I-beam or the cross-travel, as to do so would retard production. With this hoist a small man can handle the bundles of drawn wire and load them from the drawing bench to the truck, almost as quickly as he could do it by hand if he were strong enough. The truck loaded with bundles is hauled either to the next process or to storage by electric tractors as shown.



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Practical Books
For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Machinery Foundations and Erection—By Terrell Croft, Consulting Engineer, St. Louis, Mo. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City. First edition, 691 pages, price $5.00, illustrated.

Those persons interested in the design or construction of foundations for machinery and in the erection of the machinery, will find the subject covered thoroughly and practically in this volume. The volume contains a large variety and amount of data and information in a form not only easily available and usable, but a total of 773 illustrations makes the information more easily understood and applied. Numerous simple rules are given whereby foundations can be easily designed by those having a working knowledge of arithmetic.

The first division of the book is devoted to the general requirements of foundations, to formulas for proper proportions, and to the subjects of vibration and the bearing power of soils. This is followed by divisions on the design and properties of machinery-foundation components such as anchor bolts, anchors and anchor plates, anchor-plate pockets, anchor-bolt casings, and anchor-bolt templets. Foundation installation is then treated under the subjects of laying out and excavating, masonry and concrete foundations and forms therefor, and lastly, enlarging, repairing and removing existing foundations.

The next group of divisions gives specific information on the design and construction of foundations for machines of certain types. The last divisions explain the methods employed in erecting the machinery after the foundation has been built.

* * * *

The Welding Encyclopedia—Second edition, edited by L. B. Mackenzie and H. S. Card. Published by the Welding Engineer Publishing Company, 608 South Dearborn St., Chicago, Ill., 314 pages, price $5.00.

Approximately the first half of this reference book on the theory, practice and application of the four autogenous welding processes, consists of a directory of words, terms and trade names used in the welding industry. Considerable attention has been given to instructions for welding operations on the more common types of repair and production work, descriptions of modern methods of testing welds, specifications for welding wires and rods for all classes of work, and descriptions of the application of welding to the various industries, such as automobile repairing, refrigerating machinery, structural steel work and other lines. Separate chapters are devoted to oxy-acetylene welding, electric arc welding, electric resistance welding and thermit welding. Complete descriptions of each of these processes are given, followed by general operation instructions and special instructions for the application of each process to every metal which can be welded by it.

One section of the book is devoted to the various legal and insurance regulations on welding operations. A special chapter deals with the heat treatment of steel. A variety of methods of preparing joints for welding is shown in a group of charts and tables. In all, a total of 550 illustrations is used in this book. A special item of interest is a color chart which explains the proper adjustment of the oxy-acetylene flame. At the end of the book a catalog section of over 70 pages describes and illustrates standard lines of welding equipment apparatus, and brings the total volume up to 388 pages.

* * * *

Technical Expositon—By Karl Owen Thompson, A. M., Associate Professor of English at Case School of Applied Science, Cleveland, Ohio. Published by Harper and Brothers, New York City, 227 pages.

That industrial engineer who is reluctant to write for publication about the novel phases of his everyday work will find in this admirable book the answers to many of the problems such writing involves. Indeed, so complete is this comprehensive treatise that it is debatable which profession owes Prof. Thompson the more: engineering or technical journalism.

It is no secret that not the least of the tribulations of an editor is caused by the hesitancy of many well-informed constituents to contribute to the pages of his journal. All too frequently a chief engineer or a chief electrician or a master mechanic or a works manager will have stored away in his experience the details of a time-saving operation or an efficiency method of tremendous value to his contemporaries in industrial works. And yet, many times industry must await this knowledge until an editor learns of it and passes it on.

"Technical Exposition" outlines the various types of writing, though it concerns itself principally with the expository method. It is a book that any industrial engineer may read with profit. The chapter titles are: The expository method; definitions of words; sources of a technical vocabulary; formation of technical words; importance of the sentence in exposition; punctuation marks, abbreviations and symbols; methods of analyzing written material; exposition in oral expression; the business letter; journalistic exposition—the newspaper—the magazine; advertising as a method of exposition; technical reports; specifications and contracts; accessories of exposition.

Handbook of The Electric Power Club—Published by The Electric Power Club, Kirby Building, Cleveland, Ohio, 284 pages, paper bound, price 50 cents.

What information is required for the selection of the proper oil circuit breaker; what should manufacturers supply and what should customers supply under a general specification for switchboards; what detailed requirements should be included in specifications for control for a d. c. traveling crane; what are the detailed specifications for adequate inclosures for controllers; what limitations should be imposed in the use of belts and gears and two-bearing motors; what are the standard terminal markings of electric power apparatus in general; how should transformers be connected for different polarity in banks for various recognized angular displacements? The foregoing are a few of the many questions which frequently confront users of electric power apparatus and for which complete answers can be found in this handbook which contains the results of standardization work by the electrical apparatus manufacturers.

* * * *

The Diagnosing of Troubles in Electrical Machines—By Miles Walker, published by Longmans, Green & Co., Fourth Avenue and 30th Street, New York City, 434 pages, price $10.50.

A book on troubles in electrical machines by such a well-known author on electrical design as Miles Walker, Professor of Engineering in the Faculty of Technology in the University of Manchester and Consulting Engineer to the Metropolitan-Vickers Electrical Co., is a valuable addition to engineering literature. This volume reflects something like thirty years' experience in connection with the operation of electrical machines and an equal amount of time in observing their operation under varying degrees of punishment both in application and operation.

The book is divided into sixteen chapters, the headings of which give a general idea of the character of its contents. These chapter heads are: Breakdown of insulation; over heating, measurement of temperature; low efficiency; miscellaneous troubles; use of vector diagrams; alternating current generators; regulation of direct-current generators; sparking at the brushes; direct-current motors; defects in synchronous converters; sparking at the brushes on synchronous converters; other defects in synchronous converters and motor-generators; induction motors; use of the oscillograph in commercial testing.

The chapter devoted to "Miscellaneous Troubles" will be found interesting to the practical man in view of the fact that it takes up an analysis of electrical and mechanical troubles that are usually treated lightly in design texts. Professor Walker discusses in this chapter such subjects as running balance; the theory of balancing; the deflection of shafts; taking damping forces into account; eddy-currents in journals and bearings; magnetization of shaft by the field magnets; cure for loose tooth laminations; insufficient support of insulation; magnetic source of noise; mechanical source of sound, and other problems.

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(Continued from page 207)

Fourteen-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, TOP-TO-TOP, CHART P

Coils	Group Numbers																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	2	1	1	2	1	1	2	1	1	2	1	1	1	1	2	1	1	2	1	1	2	1	1	2
48	2	2	2	2	1	2	2	1	2	2	1	2	2	1	2	2	2	2	1	2	2	1	2	2	1	2	2	1
54	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2
60	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2
62	3	2	2	2	3–1	2	2	3	2	2	2	2	2	2	3	2	2	2	3–1	2	2	3	2	2	2	2	2	2
72	2	3	2	3	3	2	3	2	3	2	3	3	2	3	2	3	2	3	3	2	3	2	3	2	3	3	2	3
80	2	3	3	3	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3	2	3	3	3	3	3	3
86	4–1	3	3	3	3	3	3	3	3	3	3	3	3	3	4–1	3	3	3	3	3	3	3	3	3	3	3	3	3
90	4	3	3	3	3	3	3	4	3	3	4–1	3	3	3	4	3	3	3	3	3	3	4	3	3	3	4–1	3	3
96	4	3	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3
104	4	4	4	4	3	4	4	3	4	4	3	4	4	3	4	4	4	4	3	4	4	3	4	4	3	4	4	3
108	3	4	4	4	4	4	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4	3	4	4	4	4	4	4
120	4	4	4	4	5[k]	4	4	5[k]	4	4	5[k]	4	4	5[k]	4	4	4	4	5[k]	4	4	5[k]	4	4	5[k]	4	4	5[k]
128	4	5	4	5	5	4	5	4	5	4	5	5	4	5	4	5	4	5	5	4	5	4	5	4	5	5	4	5
135	5	5	5	5	5–1	5	5	4	5	5	4	5	5	5–1	5	5	5	5	4	5	5	5–1	5	5	4	5	5	4
144	6	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5
150	6–1	5	5	5	6	5	5	6	5	5	6	5	5	6	5	6–1	5	5	6	5	5	6	5	5	6	5	5	6
156	5	6	5	6	6	5	6	5	6	5	6	6	5	6	5	6	5	6	6	5	6	5	6	5	6	6	5	6
160	6	6	6	6	5	6	6	5	6	6	5	6	6	5	6	6	6	6	5	6	6	5	6	6	5	6	6	5
180	7	6	7	6	6	7	6	7	6	7	6	6	7	6	7	6	7	6	6	7	6	7	6	7	6	6	7	6
216	8	8	8	8	7	8	8	7	8	8	7	8	8	7	8	8	8	8	7	8	8	7	8	8	7	8	8	7
240	8	9	8	9	9	8	9	8	9	8	9	9	8	9	8	9	8	9	9	8	9	8	9	8	9	9	8	9

[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

THREE-PHASE, TOP-TO-TOP, CHART X

Coils	Group Numbers																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
48	2	1	1	1	1	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1
54	2	1	2	1	1	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1	1
60	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2	1	2	1	2	1	1	2	1	2	1	1	1	1	2	1	2	1	1	1	1	2	1	2	1	2	1	1
62	2	1	2	1	2	1	1	2	1	2	1	2–1	2	1	2	1	2	1	2	1	1	2	1	2	1	2	1	2–1	2	1	2	1	2	1	1	2	1	2	1	2	1	1
72	1	2	1	2	2	2	2	1	2	1	2	2	2	1	2	1	2	2	2	2	2	1	2	1	2	2	2	2	2	1	2	1	2	2	2	1	2	1	2	2	2	2
80	1	2	2	2	2	2	2	2–1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2–1	2	2	2	2	2	2
86	2	2	2	2	3–1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3–1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
90	3	2	2	2	2	2	2	3	2	2	2	2	2	3	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3	2	2	2	2	2	2	3	2	2	2	2	2	2
96	3	2	3	2	2	2	2	3	2	3	2	2	2	3	2	3	2	2	2	2	2	2	3	2	3	2	2	2	3	2	3	2	2	2	2	3	2	3	2	2	2	2
104	3	2	3	2	3	2	2	3	2	3	2	3–1	3	2	3	2	2	3	2	2	3	2	3	2	3	2	3	2	3–1	3	2	3	2	3	2	2	3	2	3	2	3	2	2
108	2	3	2	3	2	3	3	2	3	2	3	3	2	3	2	3	2	3	2	3	3	2	3	2	3	2	3	3	2	3	2	3	2	3	2	2	3	2	3	2	3	3
120	2	3	3	3	3	3	3	2	3	3	3	3	3	2	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3
128	3	4–1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4–1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
135	4	3	3	3	4	3	3	3	4	3	3	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	3	3
144	4	3	4	3	4	3	3	4	3	4	3	3	4	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	3
150	3	4	3	4	3	4	4	3	4	3	4	4	3	4	4	3	3	4	3	4	4	3	4	3	4	3	4	4	3	4	3	4	3	4	4	3	4	3	4	3	4	4
156	3	4	3	4	4	4	4	3	4	4	4	4	3	4	3	4	4	4	4	4	4	3	4	3	4	4	4	4	3	4	4	4	3	4	4	4	4	3	4	4	4	4
160	3	4	4	4	3	4	4	4	4–1	4	4	4	4	4–1	3	4	4	4	4–1	4	4	4	3	4	4	4	4	4	3	4	3	4	3	4	4	4	4	3	4	4	4	4
180	5	4	5	4	4	4	4	5	4	4	4	5	4	4	5	4	5	4	4	4	4	5	4	5	4	4	4	4	5	4	5	4	4	4	4	5	4	5	4	4	4	4
216	6	5	5	5	5	5	5	6	5	5	5	6	5	5	5	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5	6	5	5	5	5	5	5
240	5	6	5	6	6	6	6	5	6	5	6	6	6	6	5	6	5	6	6	6	6	5	6	5	6	5	6	6	5	6	5	6	6	5	6	5	6	5	6	6	5	6

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How to Group Coils

(Continued from page 207.)

want to connect it for ten poles, three phase, two parallel.

After killing the two coils according to Rule II—(b) we now have 60 active coils. Following Rule III we divide the number of coils by the number of groups. Then 60÷30=2, and there is no remainder. Therefore, each group will have two active coils. Also there will be two dead coils, as discussed in the example for Rule II—(b).

Example of Rule III—(b):

Suppose now we have the 62-coil winding and want to connect it for eight poles three-phase series. As shown under the example for Rule II—(b) we should kill two coils, leaving 60 active coils. Then, according to Rule III, we divide the number of coils by the number of groups. This gives 60÷24=2 and a remainder of 12. According to (b) of Rule III this means that the grouping will be unequal, and we must pass to Rule IV.

Example of Rule IV:

Under Rule IV an example was given of finding the number of large coils in a winding. As another case we may take the winding just mentioned in the example for Rule III—(b). We find that in this eight-pole winding when we divide the active coils by the number of groups we have a remainder of 12. This means that twelve of the twenty-four groups will be large groups having three coils each. The other twelve groups will have two coils each. Now the next job is to distribute the large coils in the proper way.

This is the second article of a series on connecting induction motors of two to twenty-four poles, two-phase and three-phase. The series will be continued in the next issue of INDUSTRIAL ENGINEER.

Electric Traveling Cranes

(Continued from page 180.)

are entirely independent of each other. The best combination to use on a crane is one in which the cam-contactor type of controller and grid resistors for the larger-size motors or tube resistors for the smaller motors, are used. The wire in the tube resistors should be wound on insulated iron pipe as the pipe has no tendency to crack under heat.

As a protective device, a fuse in itself is not sufficient because renewals are expensive and because the operator or repairman will usually make a temporary repair with heavy wire and then forget about it. Circuit breakers must be set too high for normal operating conditions and this does not give any protection against continuous small overloads. The protective panel to be used on a crane should be equipped with no-voltage release coils, overload trip coils for each motor, and over-travel limit contactors for the hoists. On the panels now installed on the cranes, these coils actuate plungers which in turn operate contactors on the various circuits. The plungers are controlled by oil dashpots which allow a momentary overload, but function on any sustained overload. The parts which require renewals are the trip coils and the contactor tips, although these normally have a long life. The main contactors are controlled by a push button within ready reach of the operator to be used in case of any emergency.

The over-travel limit switches are geared to the hoist mechanism and are connected in series with the trip coils actuating the contactors in the hoist circuit, which on opening automatically short circuit the armature and set up a dynamic braking.

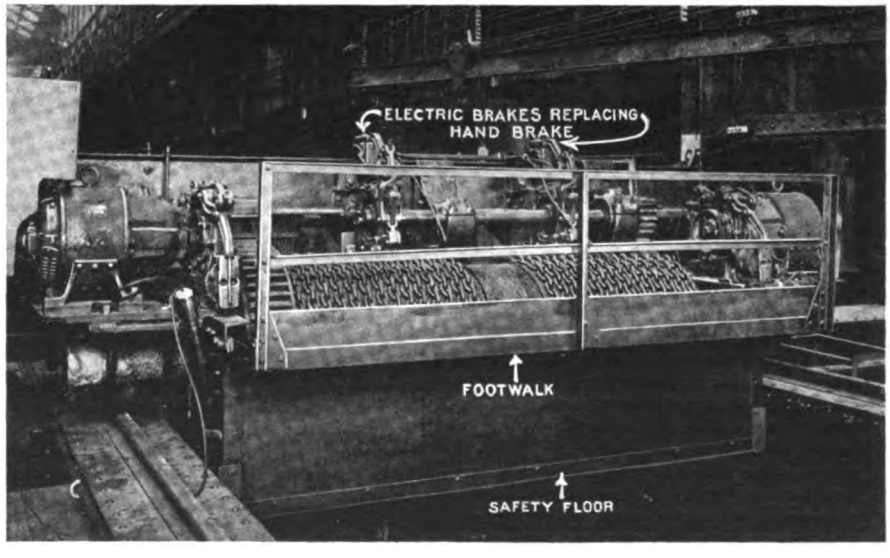
Both span wires and bus-bar structures are in use on the bridges, but we favor the former because of simplicity, low initial cost and ease of repairs. If heavy, hard-drawn copper wire is used these wires will last a long time and give little trouble.

All wiring on cranes is now being done in conduit in preference to open wiring, cables or wooden moulding.

"An ounce of prevention is worth a pound of cure," is an adage that has proven its value. With this thought in view, the Westinghouse Company has crane inspectors whose duties are to make regular monthly inspections of each and every crane, paying particular attention to the chains, wire ropes and all other parts whose failure would endanger life, and to make suggestions for improvements. They are supplied with printed forms upon which they note their findings and recommendations. Some of these forms are shown in Figs. 4 and 5. These reports are sent to the foreman of the crane repair department for his information and guidance. This, however, does not relieve the operator from his responsibility of reporting any trouble or fault with the equipment.

Fig. 7—A sheet-metal safety floor was installed under this trolley.

Footwalks also have been added at right angles to the girder. On this trolley the mechanical brake was removed and replaced with two electrically operated brakes. When this photograph was taken the wiring had not been completed.



National Electrical Code Changes

(Continued from page 196.)

are controlled as a unit, the pair of motors may be protected as one motor. If, however, these motors are doing different work and are controlled by separate controllers, each motor must be protected by an automatic cutout.

OIL SERVICE SWITCHES REQUIRE AIR-BREAK DISCONNECT SWITCHES

Where oil switches are used as service switches on wires taken from primary lines, a disconnecting switch of the air-break type must be installed between the supply and the oil switches. Switching and motor rooms for 600-volt to 5,000-volt circuits must be closed to unqualified persons.

So far as fuses are concerned the major addition to the code is the requirement of identifying marking to indicate their rating. For 250-volt fuses of 15 amp. or less a navy-blue label is required, and for fuses of greater rating green labels.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

National Lamp Works of General Electric Company, Nela Park, Cleveland, Ohio—Bulletin 42, entitled "Factory Lighting Designs," is a practical handbook for the installer of lighting equipment and was compiled by J. R. Colville. Numerous diagrams show spacing and arrangement of lights for a wide variety of ceiling heights and sizes of bays. Auxiliary, group and local lighting problems are also discussed. Four pages are devoted to a tabulation of the recommended standards of illumination in foot-candles in a wide variety of industrial conditions.

Stow Manufacturing Company, Binghamton, N. Y.—Bulletins and circulars describe the Stow line of portable electric drills and grinders as well as the type driven by a flexible shaft. Particular attention is devoted to the list of Stow emergency repair equipment particularly adapted to repair and maintenance work.

The Dow Company, Inc., Louisville, Ky. —Dow conveyors of gravity and power types for handling every kind of package and loose material are described and illustrated in a 50-page booklet. In addition to many illustrations the details of construction are also shown.

Strauss and Blum, Inc., New York, N. Y.—A small folder describes the "Sabco" 2-heat soldering iron, which is controlled by a button in the handle to give two distinct irons of different temperatures. Through this button control the temperature and wattage may be increased 20 to 30 per cent. Special tips for particular purposes are also supplied for them.

P. E. Chapman Electrical Works, Tenth and Walnut Streets, St. Louis, Mo.—Bulletin 120 describes the "Allatonce" commutator soldering machine which solders at one time all the connections of a commutator, a rotor, the long joints of container ends, or any other device which requires considerable soldering. It is claimed that it not only eliminates the slow, tedious hand soldering but also saves a large volume of solder. During its operation the motor shaft and ring insulations are protected.

The S. S. White Dental Manufacturing Company, 84 Market Street, New York City—White portable undercutting equipment, which consists of a portable electric motor with extension cord, flexible shaft and milling cutters or burrs, is described in literature supplied by this company. Grinding or polishing wheels, drills or other tools may be used instead of burrs for other work. Another booklet entitled "From Sheep Shears to Speedometers and Other Applications of a Flexible Shaft" describes the construction, operation and care of flexible shafts.

The Ohio Electric & Controller Company, 5900 Maurice Avenue, Cleveland, Ohio—Bulletin 105 describes the Ohio mill-type lifting magnet, its construction and application. Particular attention is given to the features which are claimed to give it rugged construction.

The Dayton Fan and Motor Company, Dayton, Ohio—Dayton fractional-horsepower motors for direct or alternating current of various types from 1/30 to ½ hp. are described in the booklet entitled "Dayton Motors." Of considerable interest is the space devoted to "How to Select the Proper Motor." Dimension diagrams for the different types and sizes are included.

Century Electric Company, 1827 Pine Street, St. Louis, Mo.—Bulletin 32 describes the Century alternating and direct-current fans. These are made in portable, ceiling and ventilating types. Numerous construction details are included.

The Jeannin Electric Company, Toledo, Ohio—A small folder describes the advantages claimed, the construction and operation of the Jeannin single-phase, repulsion-induction motor. These are built for all commercial voltages and frequencies in the vertical or horizontal types with either plain or ball bearings.

Chas. A. Schieren Company, 30-38 Ferry Street, New York City — A series of four-page bulletins entitled "Practical Facts About Belting" is distributed in loose-leaf form by this company. Some of the subjects taken up in the twelve installments making up this series are, for example, "Types of Drives," "Rules and Ratings," "Belt Formulas," "Care and Operation" and "Selecting the Right Belt."

The United States Graphite Company, Saginaw, Mich. — Catalog B-3, describes the U. S. G. motor and generator brushes. In addition to describing the various brushes manufactured considerable attention is given to a recommendation sheet for various types of brushes and working sketches of special brushes. Several pages are devoted to suggestions for eliminating brush trouble.

Greenfield Tap and Die Corporation, Greenfield, Mass.—A 32-page "Repair Tool Catalog" lists the various types of screw plates, taps and dies, twist drills, reamers, pipe tools and other tools manufactured by the Greenfield Corporation. Particular emphasis is placed on special sets which are especially adaptable to repair kits for repair and maintenance men.

American Abrasive Metals Company, 50 Church Street, New York City—A 4-page bulletin describes the Feralun anti-slip tread, for use on stairways, steps, floor-plates around machinery, at elevator doors and other similar places to reduce slipping hazards.

So-Luminum Manufacturing and Engineering Company, Inc., 162 West Fifty-fourth Street, New York City—A small folder describes "So-Luminum" which is claimed to be a "three-in-one" soldering, brazing and welding compound for aluminum, copper and brass. Instructions for its use and comments from users are included.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Publication 3015 is a new illustrated, 24-page booklet on the C-H "Red" lifting magnet. The construction features of the magnet are fully illustrated and described. Special mention is made of the method of control by the magnetic controller and master switch, furnished with these magnets. Numerous illustrations give evidence of the many and various applications of these magnets in industry.

Universal Conveyor Company, South Bend, Ind.—Folders describe and illustrate the use of the Universal conveyor in handling coal. Particular emphasis is laid upon the saving which may be made by the mechanical handling over moving by hand.

The Dayton Air Brush Company, 17 Maryland Avenue, Dayton, Ohio—A 20-page catalog describes the Dayton air brush for universal use. This air brush may be attached to any compressed air line to spray or flow all kinds of paints, enamel, varnish, shellac, calcimine, disinfectants, gasoline, oils, or other liquids. It has a nozzle control which may be adjusted to cover from ⅛-in. surface to 8-in. surface and so can be used for either fine finishing work or for applying rough protective covering. Repair shops will find it particularly useful in spraying insulating compounds or doing other painting.

I. G. White and Company, 115 North Desplaines Street, Chicago, Ill.—Literature describes the "Handy Pan" which is a black enameled iron tool box 4½ in. by 9 in. by 18 in., to carry tools or repair supplies around the plant. This is made either with or without compartments.

L. B. Allen Company, Inc., 4519-29 North Lincoln Street, Chicago, Ill.—A folder describes the Allen non-acid "Sodering" flux and other "sodering" specialties. These are put up as liquid, stick, paste and oil.

The Cincinnati Electric Tool Company, Cincinnati, Ohio—Catalog 18 covers the line of Cincinnati portable electric drills, and hand, bench and floor grinders and buffers for alternating or direct current. Special features of this equipment are described and illustrated.

Peerless Folding Ladder Company, Greenville, S. C.—A folder entitled "The Neglected Ladder," by W. H. Hall, safety engineer, U. S. Fidelity and Guarantee Company, gives a safety engineer's opinion on the ordinary ladder and also makes some comments on the use of the Peerless folding ladder.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

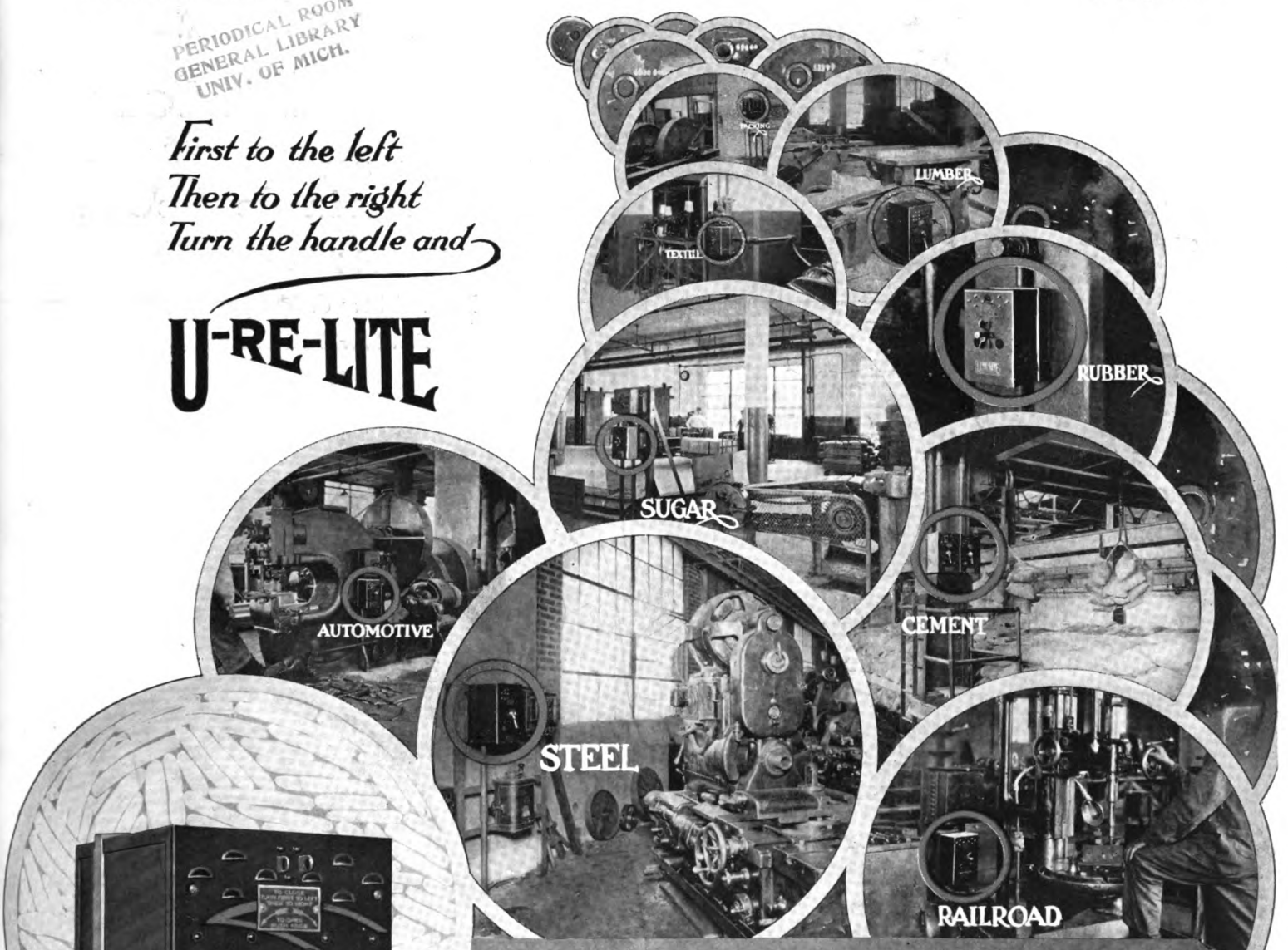
May, 1923

McGraw-Hill Co., Inc. Chicago, Ill.

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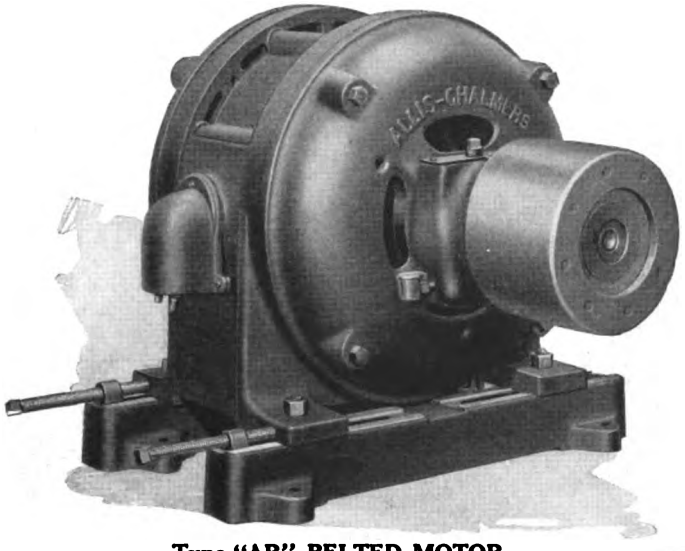
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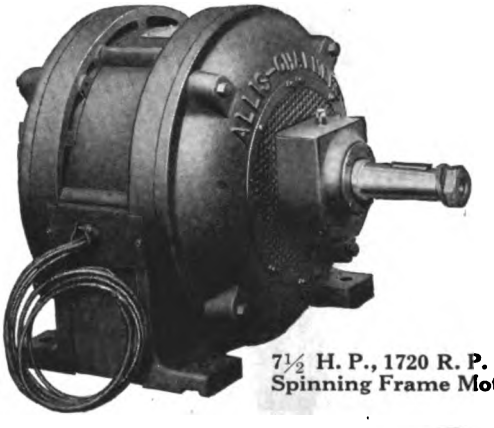
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Designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.



7½ H. P., 1720 R. P. M.
Spinning Frame Motor

Method of ventilation is very effective, resulting in even cooling and avoiding of "hot spots."

Bearings are of liberal design with spacious oilwells.

Insulation is of highest grade, stator being treated with baked-on insulating varnish, making the whole structure dust and moisture proof.

Motors are for floor or ceiling mounting being provided with very stiff and substantial rails.

Conduit terminal boxes are regular equipment.



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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, May, 1923 *Number 5*

Aweel, It's Aboot So

For ye've seen it yersel' and ye ken it as wull as me.



HERE IS a letter that I have received from my good friend Victor Orth of Gardenville, N. Y.

"Why on earth has it been and still is necessary in most plants for the maintenance electrician to keep his eyes well peeled when new work is being installed by construction gangs? It happens too frequently that he is required to take care of motors and starters in such places that an acrobat cannot reach them without tearing the works down. In such cases it is no wonder that he shows considerable irritation when he hears the engineering department's ballyhoo explain to the boss how neat and compact the whole outfit is, and make such remarks as: 'Don't you see, the motors and switches are all out of the way, and cannot be harmed or do harm?'

"I am not usually revengeful, but I would like to see some of these men tear down platforms of two-inch stuff to be able to get at a motor and then rebuild them. I have seen compensators whose fingers had to be frequently inspected put so close to a wall that I had to tie myself into a knot and try to get at them with a home-made off-set screw driver and much sulphurous language. The reason for these particular starters being so placed was to accommodate the width of the trucks being used, while but a few feet away there was plenty of spare room. Many times I have seen switches and motors set where there was sure to be drippings from pipes and condensation from steam, with no way to entirely protect them, when better locations were feasible. Other examples are panel boxes bolted close to the wall with fuse blocks bolted with nuts at the back so that in case of a grounded block there was no way of getting at the nut, and to make a replacement it was necessary to break the porcelain and cut the bolts with a cold chisel. Anyone who has tried that knows what size screws he is likely to need for the new block. Why not tap the box out in the first place and use brass screws?

"Are the engineers and layout men in our plants too proud to consult with the men who do their darndest to make their installations perform the work they were meant to do? Are they afraid to appear ignorant or uninformed? They need not be. Maintenance is a thing apart from the usual training of office and technical men. They cannot have the experience nor the chance of watching the results and behavior of installations as the maintenance man sees them, nor for so long a time, nor under all the different conditions of service. An experienced maintenance man can tell the man above plenty of things that would be of value to him, but most of them will not unbend to listen, much less ask. Can anyone suggest a reason and how to overcome this situation?"

Mr. Orth has said a mouthful and given us something to think about. Let's not let the matter drop here but write me how you have handled the situations he brings up.

Practical Pete

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A Glimpse Into the Operations in

Packingtown, Union Stock Yards, Chicago

Within an area about a mile square, a portion of which is shown below, the world's largest meat packing center has been built up. This is the fifth of a series devoted to the growth and extent of basic American industries.

ON AN average over 45,000,000 lb. of meat are consumed in the United States daily. Over two-thirds of this is raised west of the Mississippi River and consumed east of it. The big problem in connection with the packing industry is that meat is perishable and may at any minute become a total loss on the trip from the ranges to the dinner tables of our cities. When viewed strictly from the handling of meat as a food product, the packing business is an enormous industry. Around it, however, have grown extensive associated industries and specialized manufacturing processes that produce hundreds of byproducts used in almost every industry.



The beef from this Texas ranch may have been served on your own dinner table, after passing through one of the many packing centers in the United States.

The census of 1919 shows about 50 packing companies in Chicago. Chicago early became a meat-packing center. Most of the early slaughtering was for local consumption, but in 1832, 152 head of cattle were slaughtered and shipped by boat to New York.

An airplane view of a part of Packingtown and Union Stock Yards.

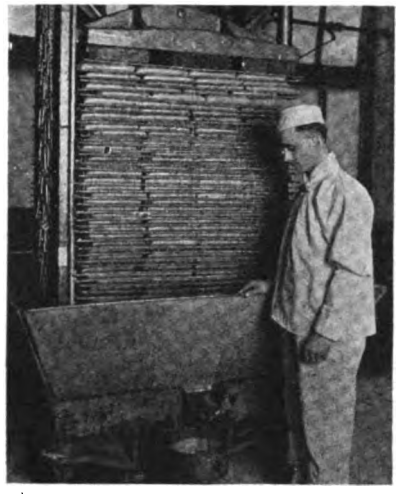
A list of some of the principal buildings and divisions shown indicate the extensive operations of a packing organization, as: (1) office of Armour & Co.; (2) office of Swift & Co.; (3) plant and office of Libby, McNeill & Libby; (4) Swift's soap factory; (5) Swift's oleomargarine plant; (6) power plant and car shops of Swift & Co.; (7) cattle killing and coolers, Swift & Co.; (8) hog killing and pork warehouse, Swift & Co.; (9) sausage and lard manufacturing division, Swift & Co.; (10) hog killing and pork warehouse, Morris & Co.; (11) cold storage warehouse, Armour & Co.; (12) wholesale market, beef killing and cooling department, sheep killing and sheep coolers, Armour & Co.; (13) freezer building; (14) power house; (15) lard refining, Armour & Co.; (16) hog killing and cutting, Armour & Co.; (17) time-keeping department, printing plant, stationery and pepsin factory, Armour & Co.; (18) oleomargarine works, Armour & Co.; (19) Armour's freezer building; (20) wool house, Armour & Co.; (21) general storage; (22) fertilizer and albumin plant, Armour & Co.; (23) glue plant; (24) several small packing companies; (25) G. H. Hammond Packing Co.; (26) Armour car shops; (27) main plant of Morris & Co.



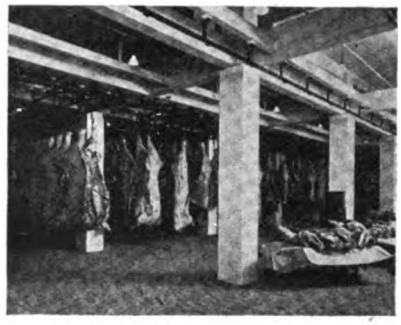
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Due to the large number of killings pharmaceutical supplies have become a very valuable by-product. In some cases it requires 5,000 steers to produce one pound.



Pressing oleo oil from beef-kidney fat. Stearine remains in the cloth bags between the presses.



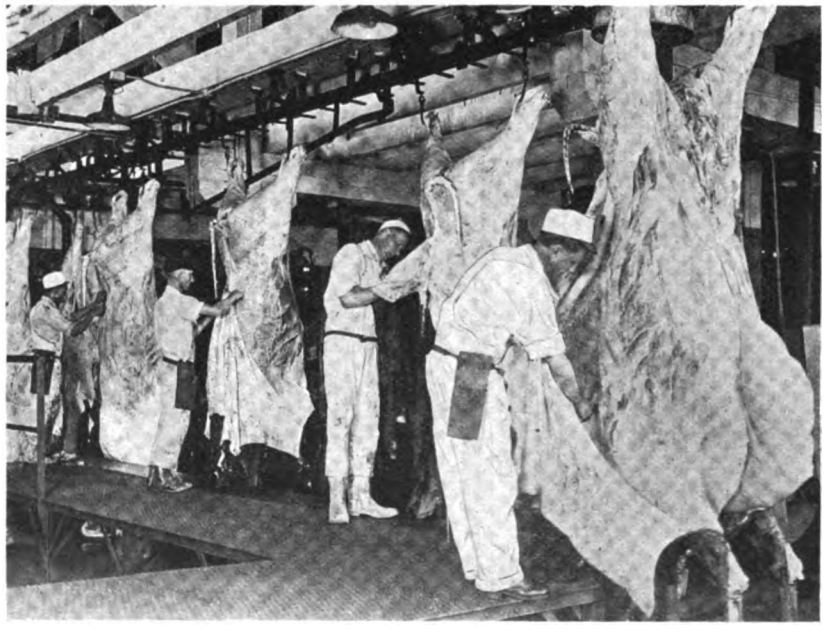
Fresh beef must be kept at a temperature of 38 deg. and must be disposed of within two weeks.

On Christmas Day, 1864, the present Union Stock Yards was opened. This now consists of about 475 acres of pens and yards with a capacity for receiving and caring for 75,000 cattle, 300,000 hogs, 60,000 sheep and 6,000 horses. The "Yards" is a separate organization, not owned or controlled by any of the packing companies. During 1922 about 16,000,000 head of cattle, hogs and sheep were received in Chicago. About 12,000,000 were slaughtered and the remainder shipped elsewhere.

Packingtown is made up of the various packing companies which surround the "Yards" and receive their live stock supplies from it. Here is located one-seventh of an entire industry which in value of product is the largest single industry in Chicago and also in the United States. According to the 1919 United States census report the value of the products of slaughtering and meat-packing industries in the United States was $4,246,290,000. About $3,774,901,000, or 89 per cent was paid for raw material, mostly live stock.

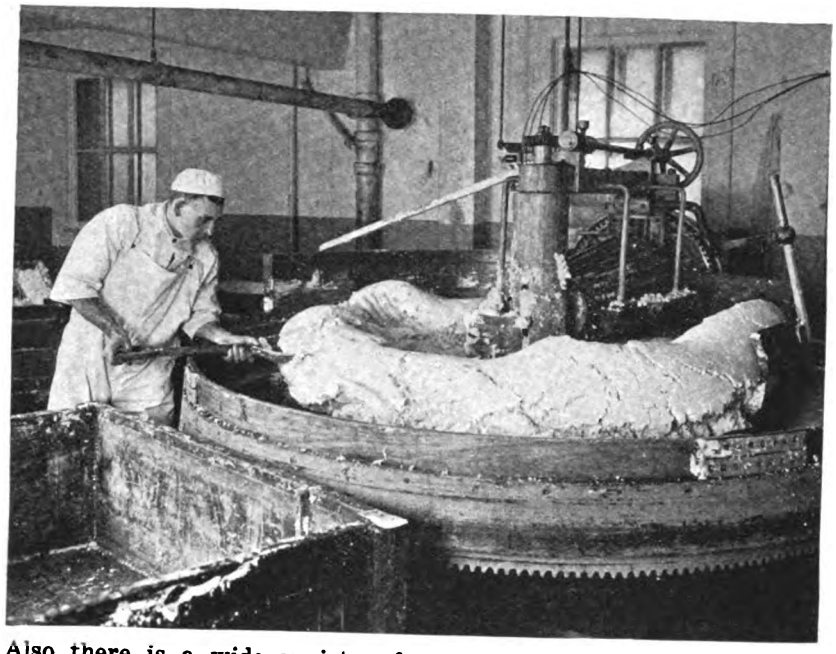
Originally, slaughtering was mostly done locally, to supply fresh meat for home consumption or to be pickled or otherwise cured for the summer or for shipping. About 1890 the packing companies took up and developed the application of mechanical refrigeration. Meat goes into mechanically refrigerated coolers, where it is chilled, because fresh meat deteriorates rapidly unless the animal heat is removed quickly. Care must be taken that it is not frozen, or if so, it must remain frozen until used. After they are killed and dressed, hogs are kept at 38 deg. for 48 hours before they are cut up into sides, hams, and so on. Fresh beef is also kept at 38 deg. but cannot be kept in storage for over two weeks.

There are many peculiarities incidental to the packing business which are radically different from conditions found in many other industries: from 85 to 89 per cent of the selling price is expended for raw material, which leaves only a narrow margin for cost of manufacturing, transportation and distribution to retail butcher shops. The packers pay cash and sell on time. Some companies each pay out over $1,000,000 a day for live stock. Too, the packers buy live and sell dressed. A 1,000-lb. steer will dress only about 550 lb. of beef, and a 250-lb. hog only about 185 lb. of pork. A dressed lamb is only about 50 per cent of its live weight. Also, the cuts which are in greatest demand are only a small percentage of the whole animal. Some of these cuts sell at a relatively higher price and other parts of the animal which are less in demand must, of course, sell at a lower figure to be sold at all.



One of the valuable by-products of the industry is the hides of the beeves. These must be removed very carefully and inspected as any holes cut into the hide decreases its value. Note on the butcher's hip the sheath for his knife.

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Here the oleomargarine is "worked," that is, the granules are kneaded together, the necessary amount of salt is worked in and the excessive moisture worked out. The trucks and machines are sterilized with live steam daily.

Also there is a wide variety of grades of meat; for example, there are twenty-seven grades of beef, each of which commands a different wholesale price.

An old saying is that the packing houses use everything but the pig's squeal. However, much cannot be recovered; for example, in a 1,000-lb. beef 30 per cent or 300 lb. is water. The most valuable byproducts are the fats, beef hides, sheep hides and wool. The excess fats are worked up into soap and oleo for oleomargarine; the hides are disposed of to tanneries and the wool to woolen mills. Other inedible byproducts are other fats which are made into inedible oils, tallow, bone, horns, and fertilizer made from otherwise unusable parts.

Because of the large amount of these byproducts on hand the packing companies have been forced to develop organizations which would not only make these up into finished products but also promote the sale of them. For this reason they have developed many side lines, such as cleaning powders; curled hair for upholstering; brushes; glue from bones and horns; case-hardening material and novelties from bone; animal feed and albumin, from which is made a weatherproof glue, from blood; sausage containers, gold beater's skins, parchment, violin strings and other products from casings; pharmaceutical products from various glands and organs of the animals, and fertilizer from the miscellaneous left-over materials not usable in any other way. In using these up the packing companies have been forced to go so far as to use the glue in making sandpaper, to make buttons from the bones, and many other products which on the surface might appear as in no way related to the packing industry. In this way the industry has developed many lesser industries. Nearly every one of the larger packing organizations has its individual soap works, oleomargarine plants, fertilizer plants, glue works, and so on, in addition to the packing plant proper.

The Editors desire to acknowledge the assistance of the Institute of American Meat Packers in the preparation of this article.

Soap, one of the big byproducts of the packing industry, is being cut into bars and stamped with the trademark name, in the illustration at the right. Below is shown the sandpaper drying room, where one packing organization uses much of its excess glue.





One of the steps in making curled hair for upholstering is to twist it up into these ropes.



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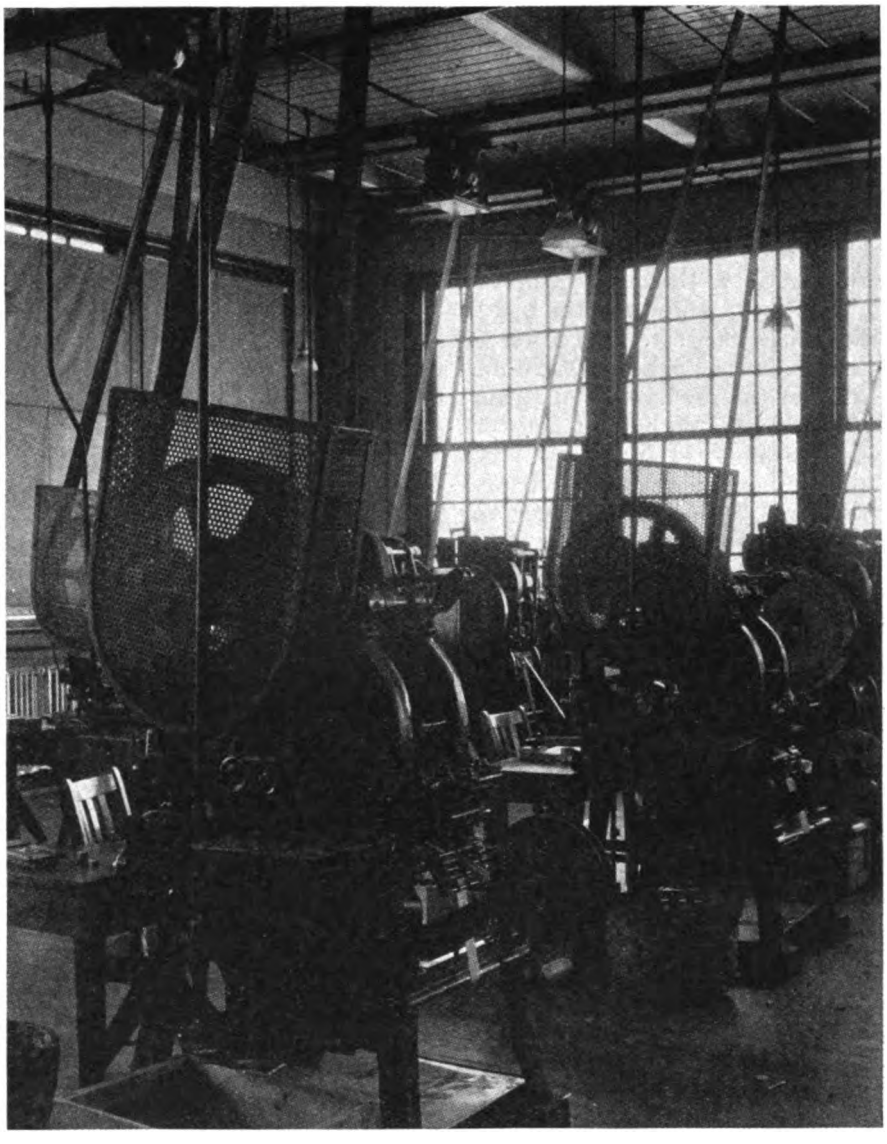
WITHOUT EFFICIENT and systematic inspection and care, dependable service from motors and other electrical equipment is, in most cases, exceptional. In this article Mr Knowlton shows how definite placing of the responsibility for maintenance work in the plant of the Dennison Manufacturing Co., has greatly reduced interruptions of service, increased production and prevented fires caused by defective equipment.

Here Are Some

Results of Thorough Inspections

And How Increased Production and a Marked Reduction in Operating Troubles Have Followed

By H. S. KNOWLTON
Contributing Editor, Industrial Engineer



Besides thorough inspection of equipment, adequate guards and brackets on motors are provided to prevent belts flying off and injuring operators.

FOR many years works engineering has received constant and thorough attention at the factory of the Dennison Manufacturing Company, Framingham, Mass. This company manufactures upwards of 2,000 different products, including tags and paper specialties in great variety. From small beginnings about three-quarters of a century ago, the company has expanded until it now occupies a number of large buildings and employs about 2,500 persons. The problems of electrical service maintenance have become of increasing importance as the years have passed, and through the courtesy and the assistance of the company, the writer has been enabled to compile this account of some of the more recent electrical betterment work looking toward the maintenance of continuous production as it is carried out in this plant.

Nearly 800 electric motors are in service, ranging in size from 75 hp. to 1/16 hp., with a total rating of about 1500 hp. Most of these motors are of the direct-current type, and about half are of the variable-speed type. Although in all commercial factories sustained production is important, it is particularly so in a plant making the variety of products here concerned, with productive departments extending over considerable areas and with raw material consuming large quantities of paper and cardboard stock with their incidental requirements of cleanliness in processes and fire protection throughout the establishment.

During the past year the inspection of motors, wiring and control equipment has been made more definite and regular through the assignment of one man to this particular detailed service. Formerly the company's chief electrician endeavored personally to inspect all motors as regularly as possible. But it was decided some months ago to place the immediate responsibility for this work upon an electrical maintenance staff to insure a greater degree of preventive inspection than was possible under the old arrangement. As a result the time lost from motor and control failures has been substantially reduced, and in one department where occasional slight fires had occurred from the ignition of lint by sparks from commutators or other causes, not a single fire has taken place since the inauguration of the new inspection system. It is stated by representatives of the company that the assignment of one man to the inspection of motors, control and wiring, has unquestionably paid for itself in decreased operating troubles and better sus-

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Fig. 1—This typewritten form is given to the inspector. He checks his inspection on each machine and makes note of any repairs that are necessary.

Date.....

The following list of motors and controllers to be thoroughly cleaned and necessary repairs made in Dept. 21, 9-2-3; and Dept. 25, 9-2-3.

MOTOR #	CONTROLLER #	MACHINE #	REMARKS #
5158	3734	1305 Blower	
4811	No controller	4657	
4747	4748	4751	
769	3008	Main for color room	

Return this sheet to Dept. 22 when finished.

SIGNED.....

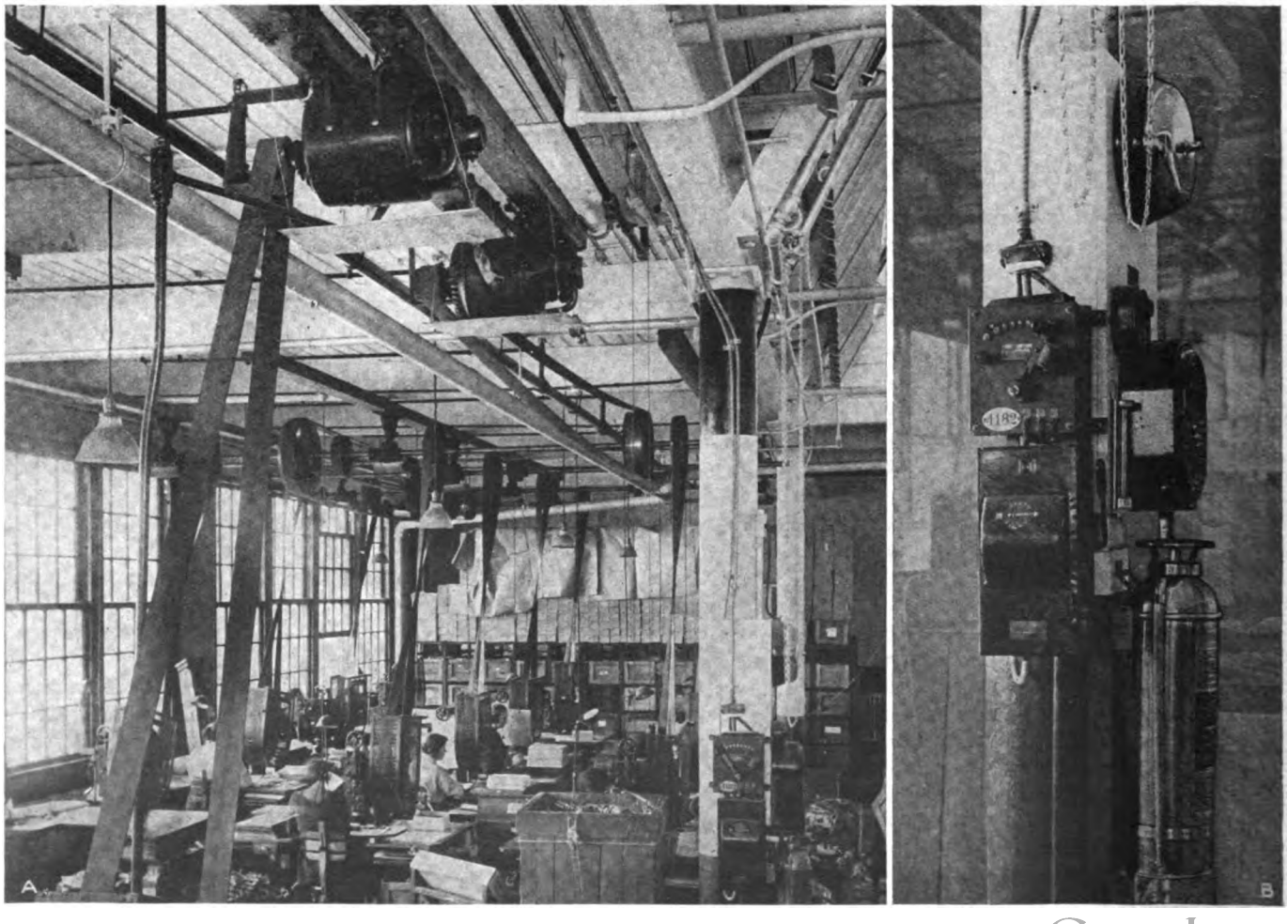
tained production in the departments.

Depending upon the class of service required of a motor, all motors now receive a thorough inspection at least every three months and in many cases monthly. The motor inspector's hours are somewhat different from the regular factory hours so that he may do part of his work when machinery is shut down. When he starts on an inspection trip, a letter-sized typewritten sheet or maintenance work-order (Fig. 1) is handed to him, directing him to clean and make all necessary repairs on motors and controllers in a specific department. Each motor, controller and machine concerned in the inspection is listed on the sheet with the company's number. Space is provided for the notation by the inspector of any remarks bearing upon his findings and work done at the time of the inspection. A check mark is entered opposite the equipment requiring no repair work. This work sheet or field report is turned into the electrical department with the completion of the work on the equipment listed. If shop repairs are required and a motor has to be removed from its location and rewound, a separate work order is prepared to cover this work.

This arrangement of work sheet to cover inspection minimizes the amount of clerical service which must be performed in connection with the inspection of motors and control apparatus, and therefore is applicable to motor inspection routine in other industries. The reduction of clerical work by inspectors and maintenance men to the minimum possible is looked upon as vital to the success of such a system in a busy plant.

Fig. 2—Note the grouping of fire-alarm, watchman's box, etc., and control in one location.

At the right is a group drive for twelve presses. On the column shown enlarged at the right are mounted the fire-alarm box and gong, watchman's box, thermometer and control for a nearby motor, all in one place.



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ELECTRICAL MAINTENANCE

1½ HP MOTOR # 5390 CONTROLLER # 5426 MACH. # 5389

DEPT. 10 BLDG. 4 SEC. 1 FL. 2

DATE	INSPECTION REPORTS	DISPOSITION
5/19/22	New Mach. additional light needed	Order sent to 12A
11/23/22	Cleaned motor and control	
	Replaced one brush	

Fig. 3—Record cards like this are kept in file for each motor. Work done on a machine is noted on this card.

In the electrical department a card record (Fig. 3) is maintained showing the date, inspection results and action taken upon every motor and associated piece of control equipment. The card is filed according to the motor rating and the factory numbers of motor and control apparatus, the location of the equipment also being stated on the card.

It has not been found necessary to prepare a detailed inspection sheet specifying every step to be taken in the inspection of a motor and its control. This routine is left to the inspector, who was trained to care for it when the change was made to the present system. The motor inspection, however, includes examination of bearings, commutators, brushes, wear of bars and brushes, condition of brush-holder as regards binding, whether oil rings turn or not, adequacy of oil supply, condition of wiring and contacts, cleanliness of motor and condition as regards heating. Usually motors are blown out by compressed air on these inspections, a portable compressor being available for the use of the inspector.

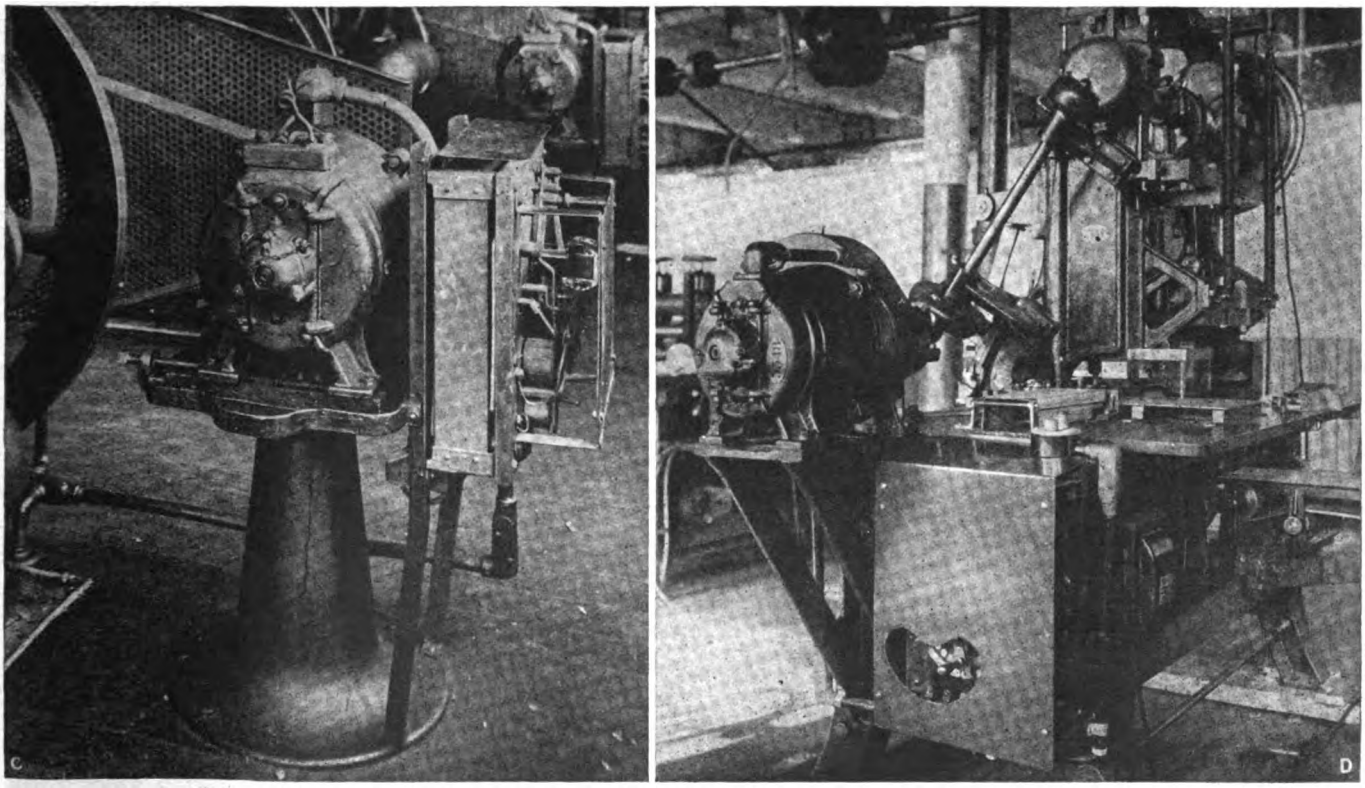
Control equipment is examined for indications of loose contacts, frayed insulation on wiring, operating temperature, condition of contacts and indications of flashing. The control equipment is also blown out with air at the same time the motor inspection is made. A test of the controller's ability to function normally is also made during the inspection, and it is under consideration to check up regularly the size of fuses in use on motors and to report these to the electrical department.

Inspection of motor and control apparatus normally begins at 7 a. m., or about 45 minutes before the plant starts regular production. This is continued until 11:30 a. m., and resumed at 12:30 p. m., the half-hour until 1 p. m. being devoted usually to odd jobs on electrical equipment which can be more conveniently performed while the machinery is not in operation. The afternoon is devoted to further inspection and repair work on the installed equipment, and unless emergencies require it, the inspection work ceases at 4:45 p. m. It has been found that many small jobs can be done during the periods of factory shut-down in early morning and at noon, which would require more or less interruption of production processes if handled during the middle of the forenoon or afternoon.

Recently particular attention has been paid to the maintenance of spare equipment and parts as a factor in assuring quick repairs. Up to and including about 35 hp., it is planned to keep on hand at least one extra motor of each leading size, so that if a breakdown occurs in the factory, prompt replacement can be effected while permanent repairs are made. About twenty-five spare mo-

Fig. 4—Two good examples of individual drive.

At the left is a drive for a job press with motor and control mounted on one pedestal. A bracket fastened at one end of the machine supports the motor at the right. Notice how both of the control panels are amply protected from injury by sheet-iron plates.



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tors are on hand, and these are of course available for use in pairs or otherwise if necessary to attain a particular rating in driving for emergency service. It is the aim of the electrical department to keep on hand one set of extra bearings for at least every size of motor, and similarly, extra sets of brushes, contacts, solenoid switches, etc. It is considered better practice to carry a few extra sets of brushes than to fall back upon cutting down brushes to size with a hack-saw in case of a shortage of a particular size.

Another step in the direction of saving time on repair work has been the decision to do the rewinding of motors and other apparatus in the factory instead of sending the equipment outside. This has been done now for some months past, and with a decided reduction in the time required to get a motor into condition for re-installation. During periods when the amount of motor winding is small, the winder who is engaged on this work is assigned to making special coils for heating service or other applications. A total of ten men, including the motor inspector and the armature winder, are employed in maintenance work of an electrical character in this plant.

A very important section of the electrical equipment in this factory is the automatic interior telephone system used at Framingham. Reliability of service is so important here that a daily inspection is made of the automatic telephone equipment. The results are indicated on a form (Fig. 6) showing line-switch tests on different numbered circuits, and the functioning of batteries, signals, and other equipment. A monthly inspection is also made of the automatic telephone equipment and the condition of motor-generator brushes, ringing machine brushes, commutator conditions, lubrication conditions and other points are noted. The monthly inspection is recorded on a sheet covering all the major points for which the inspectors look. Special attention is paid to checking off the lubrication of important parts of the moving switch mechanism which selects the called numbers. This form, which is shown in the accompanying table, is an excellent guide for the inspector. It lists the various things he must do. As he must check off each item on the form, it keeps him from forgetting any points. This telephone inspection is a highly specialized task and it is normally handled alternatively by two inspectors specially trained to handle these details. This arrangement insures adequate inspection under varying conditions. The system has resulted in a much more reliable telephone service within the factory.

In its earlier days, the Dennison factory was chiefly a group-driven installation, but within the last ten years the use of individual motors has greatly increased, and the tendency is gradually toward the elimination of the group drive. In many departments the advantages of being able to maintain production regardless of the interruption of service at a single motor, the increased cleanliness of individual driving, and the more flexible speed control secured by separate machine powering, are controlling arguments for the change. Along with the increasing use of individual motor drives has gone a careful study of the plant from the standpoint of safety engineering, and the installations embody an unusual degree of protection, both to the employe and to the apparatus.

In the following illustrations of typical improved drives adopted at the Dennison plant, it will be noted that the use of rigid or flexible armored conduit is general. The location of control equipment is out of the way of passers-by or else protection against contact has been afforded, and the use of push-button types of control has been very widely applied. It is interesting to note that since the use of individual motor drives became general in the plant, it has become possible for two belt-maintenance men to inspect (every three months) all the belts in the factory during the noon hour.

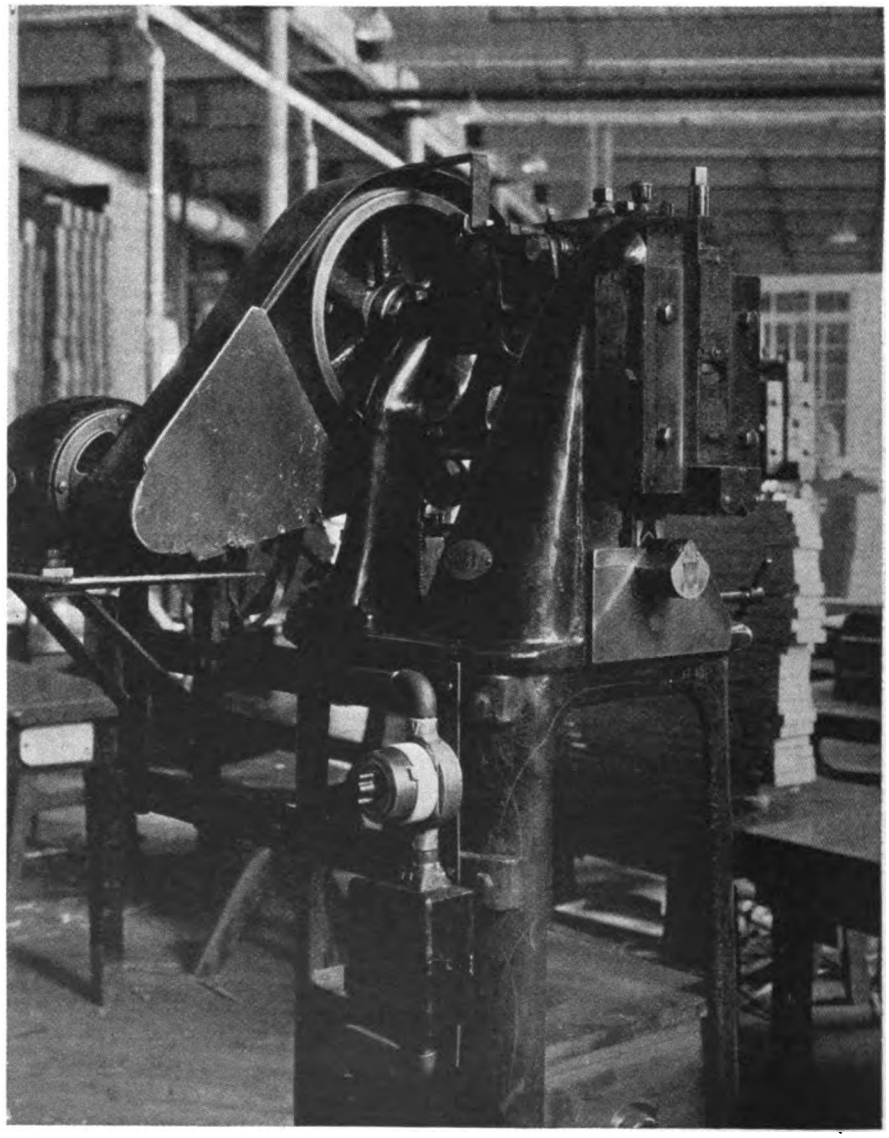


Fig. 5—Saving of space and protection of the operator from injury characterize this method of mounting the motor for individual drive.

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The mounting of the motors on machines formerly driven off line shafts by belts has been facilitated by the wide use of angle-iron and strap-iron brackets formed or selected on the premises, and motors in general are located conveniently for both inspection and light repair work.

A well-arranged but now passing type of installation is illustrated in Fig. 2 which shows a group drive of a dozen Perkins presses. A 3-hp. motor mounted on two hard-pine ceiling beams drives a shaft from which the group is in turn operated. This particular drive is a well-segregated group, but in case of motor trouble all twelve machines are down. There is more or less obstruction caused by the overhead belting, and conditions in general are inferior to the direct belt drive which is used in the same department.

Similar types of machines are driven through an individual belt by a 1-hp., 1200-r.p.m. motor mounted on 4-in. by 6-in. hard-pine ceiling timbers, with flywheel and belt guard at the machine level. The wiring is carried to the motor in rigid conduit run vertically from the floor, and a starting and stopping switch is placed within easy reach of the operator. The contactor switches required in connection with the push-button control used here are mounted behind protective screening supported by 1¼-in. by ½-in. strap-iron. A U-shaped belt hook at the side of the motor protects the operator and others in case a belt should slip off the motor pulley. The independence of these drives is in striking contrast to the former group system.

Two good individual drives are shown in Fig. 4. A compact mounting of motor and control equipment is shown at *C*, this being a job-press motor (*Continued on page 261*)

MONTHLY INSPECTION OF AUTOMATIC TELEPHONE EQUIPMENT

Clean, Oil and Inspect the Equipment Mentioned Below

POWER EQUIPMENT

Question	Yes or No	Remarks
Motor Generator Starting Operation Satisfactory?		
Motor Generator Brushes Worn Normally?		
Motor Generator Commutator Clean?		
Circuit Breaker Operation Satisfactory?		
Motor Generator Oiled With Medium Motor Oil?		
Change Ringing Machines?		
Ringing Machine Brushes Worn Normally?		
Ringing Machine Spring Adjustment O. K.?		
Ringing Machine Commutator Worn Normally?		
Ringing Machine Commutator Clean?		
Solenoid Charging Switch Operation Satisfactory?		
Ringing Machine Bearings Oiled With Light Engine Oil?		
Ringing Machine Worm Drive Oiled With Oildag?		
Notes		

MASTERSWITCH EQUIPMENT

Question	Yes or No	Remarks
Governor Work Oiled With Clock Oil?		
Governor Bearing Oiled With Clock Oil?		
Driving Segment Oiled With Oildag?		
Control Segment Oiled With Oildag?		
Locking Armature Pivots Oiled With Oildag?		
Locking Relay Armature Pivots Oiled With Oildag?		
Solenoid Plunger Bearing Oiled With Oildag?		
Main Shaft Bearing Oiled With Oildag?		
Connecting Link Oiled With Oildag?		

SELECTOR AND CONNECTOR EQUIPMENT

Question	Yes or No	Remarks
Shaft Bearings Oiled With Oildag?		
V. & N. Ratchet Oiled With Oildag?		
V. & H. Pawl uides Oiled With Oildag?		
D. D. Bearings Oiled With Oildag?		
Spider Bearings Oiled With Oildag (Armature)?		
Escapement Oiled With Oildag?		
Notes		
Date.....	Inspected by.....	

Fig. 6—Daily inspection of automatic telephones is recorded on this sheet.

A monthly inspection also is made in accordance with the table which is shown at the left of this sheet.

JOB #.....

DAILY INSPECTION OF AUTOMATIC TELEPHONE EQUIPMENT.

LINESWITCH PLUNGE-IN TEST	NO.	200 BOARD 1	2	3	4	5	6	7	8	9	10	300 BOARD 1	2	3	4	5	6	7	8	9	10
TWO GROUPS OF EIGHT CONSECUTIVE NUMBERS ON EACH BOARD TO BE TESTED ON ALL TRUNKS	301	✓							×												
	302		✓																		
	303			✓																	
	226						×														
CONNECTOR TESTS																					
SELECTOR TEST																					

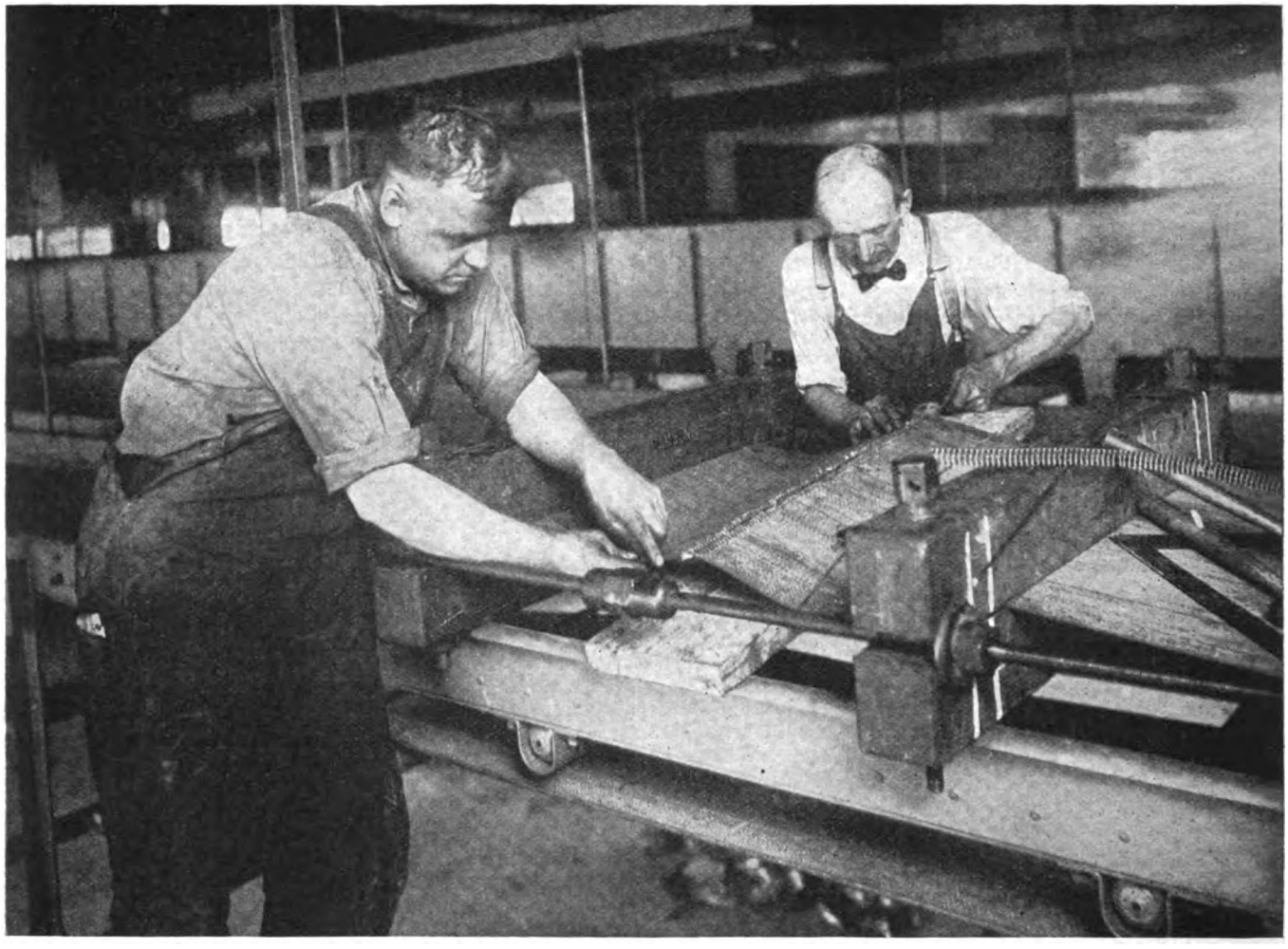
NOTES Lineswitch 226

TESTS	YES	NO	REMARKS
BATTERY VOLTAGE O. K.			
LINESWITCH GUARD SIGNAL O. K.			
FUSE ALARM SIGNAL O. K.			
RELEASE SIGNAL O. K.	•		
M. D. F. SIGNAL O. K.			
MASTER SWITCH SPEED O. K.			
MASTER SWITCH ALARM O. K.			
RINGING GEN & BUSY O. K.			
M. B. & O. M. CROSSED			

NOTES

DATE..... INSPECTED BY.....

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Here a large conveyor belt is being connected by an "Alligator" flexible lacing. A job like this requires heavy belt clamps.

Some Hows and Whys of

Servicing Industrial Belts

So as to Eliminate Time Losses, Reduce Belt Trouble and Give Information for Selecting the Right Belt

By FRANK E. GOODING
Associate Editor, Industrial Engineer

GOOD belt service is no accident. It is only when belts are chosen with the idea of getting the proper belt for the conditions under which it operates that ordinary troubles which are connected with belt service are eliminated. However, in any case belts require some attention. Ordinarily, the operation of lacing a belt is an item of small expense; the big items of expense are an idle machine and the time of the operator, both of which are lost while the belt receives attention. A good belt man can do much to reduce the amount of idle time connected with repairing belts. Practically every machine is idle at some period, such as when changing jobs, making adjustments or other similar work. A belt man who knows that a belt is giving way can, before it has come to the point where it interferes seriously with production and forces a change, plan to do the necessary work during these idle periods. In one plant, for example, the belt man, in his inspections around the plant, locates the belts which are giving way and fixes them during the noon hour, when the work does not interfere with production. He takes his own noon hour at a different time from the rest of the plant.

ALTOGETHER too often it is only when belts give trouble that they receive any attention. However, belt difficulties, like many other shop troubles, may be anticipated and frequently decreased, if not prevented, by proper servicing as explained in this article.

As mentioned, the larger proportion of the work in connection with servicing belts consists of joining them. In general there are three methods for doing this: A belt may be connected by flexible lacings, rigid connections, or by splicing endless.

The most common type of flexible

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lacing is by rawhide. Practically every belt man has his own preference as to ways of lacing, but several of the various methods which have worked satisfactorily are shown in the illustration on page 240. In making rawhide lacings care must be taken so that too much of the cross-section of a belt is not punched out by the holes. Also holes should not be too near the edge or end of the belt and should be even and line up. It is also advisable that the lacing run lengthwise of the belt on the side which faces the pulley. A rawhide lacing, properly made, is very effective in its operation over a pulley.

Manufacturers of fabric belting seldom recommend the use of rawhide lacing because punching the holes with the ordinary belt punch cuts the fabric. Where rawhide lacing is used it is best to punch holes in the fabric belt with an awl instead of cutting with a punch, as is ordinarily done with leather belt. Soft wire lacings are also used very frequently for joining belts. One advantage of this is that it does not require as large a hole as does a rawhide lacing. A disadvantage lies in that in case one strand of the wire lacing should break it leaves a dangerous sharp point which is liable to catch on the clothing of those who work near the moving belt.

Some of the various types of hinged flexible lacings are used in many plants. One of the chief advantages of these is that they can be applied very quickly. With these lacings it is not necessary to punch holes but only to see that the belt is cut square and the lacing is applied square. Various methods are used for applying the different types of these lacings, such as special machines, clamping in vises, a hammer, and other methods. These operate very satisfactorily if care is exercised in putting them on properly. Examples of these lacings properly and improperly applied are shown on page 238. They give flexible joints for passing over pulleys and may be used over pulleys of small diameter and in connection with idlers.



Nine tools which any belt man will find useful.

Although these nine tools are not all that a belt man could use, he will find these, listed by the Chicago Belting Company, convenient. They are: (1) Splitting gage; (2) belt knife; (3) glue brush; (4) turning steel; (5) tape; (6) heeler; (7) scraper; (8) finger steels; (9) screw driver. Other tools which will be necessary are belt clamps and presses and glue pots.

A method of attaching a fastener to the end of a belt without sacrificing in some degree one or more of its qualities, such as strength, flexibility or thickness, has not been invented. The principal one to suffer has been the strength of the belt itself.

Since wire lacing came into use, it has been argued by some that the belt fibres are simply spread by the wire and the belt strength not impaired. Actual experience, however, does not support this theory for belts, particularly thin ones, frequently tear off through the line of perforations, which would not be the case if the belt strength had not been weakened. One manufacturer claims that the solution of this is to zigzag or stagger the perforations of the belt so as to get as few as practical in a straight line, and these as far apart in each direction as possible.

In the hook type of lacing an important factor is the angle at which the points enter the belt. Failure of the joint is usually due to the hooks lifting or pulling out. It is evident that there is an angle of penetration at which the resultant pull on the hook will be equally divided between the leg and the joint and any tendency to lift be neutralized, and it is, therefore, desirable to approximate this angle in practice as closely as possible. For this reason hooks too small for a belt do not clinch properly or get this best angle.

Crystallization is frequently referred to as an objection to wire lacing. Actual experience, however, proves that breakage from this cause is the exception rather than the rule, and it is a fairly well established fact that when it does occur, it is due to the use of too large or too heavy a hook. Wire will stand reversal of strains or bending within its elastic limit without damage for an indefinite period, but if large heavy hooks are put into a thin belt running at high speed over small diameter pulleys, crystallization may be, and should be expected.

The principal cause of breakage of hooks, however, is from wear and it is of the utmost importance in securing satisfactory results, that the wires be imbedded in the surface of

No _____

BELT RECORD CARD

Chas. A. Schieren Belt Record System

PLANT	DEPT	DRIVE or MACHINE

DRIVE		BELT
Driver	Diam. x Face	Width
	R P M.	Tape Length
Driven.	Diam. x Face	Ply
	R P M.	Brand
Center Distance		Manufacturer
H P		Date Installed
Angle Drive		Date Taken Off
Open or Crossed		First Cost Belt
Tight Side		Maintenance Cost
Shifted		Total Cost Belt
Surrounding Conditions		Length Life
		Cost Per Foot Per Year

Remarks

Inspection Date	Work Done	Date Tightened	Amount Taken Out	Time Required	Maintenance Cost
					(Over)

Without some record such as this card the belt user can only guess at the service his belt is giving.

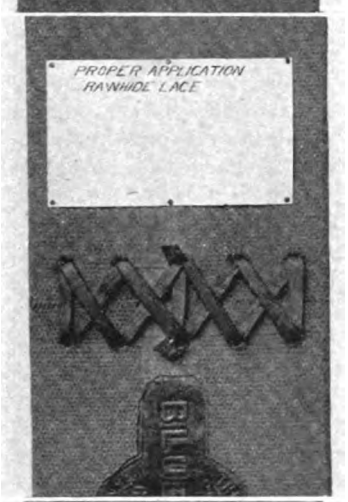
When the record card shows that a belt is causing an excessive amount of trouble and requiring too much maintenance, it is worth investigating to see whether the proper belt is used for the work. Additional entries are made on the back of this card. This is used by the Charles A. Schieren Company.

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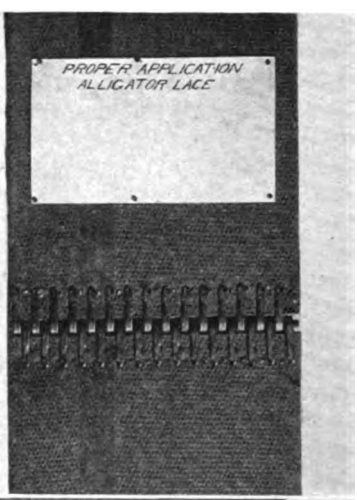
Proper and Improper Applications of Belt Fasteners

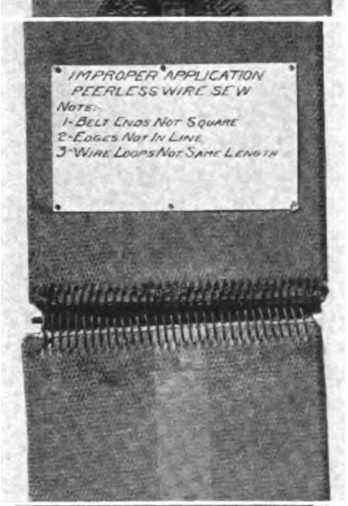
Any belt man who is proud of his ability as a mechanic would be ashamed to leave such evidence of his poor workmanship as is shown in some of the illustrations reproduced here by courtesy of The Goodyear Tire and Rubber Company. These companion pictures emphasize by contrast. The card on each belt indicates what was done wrong. Practically all of the shortcomings could be summarized in the one word—carelessness. Each of these fasteners operates satisfactorily if the right size is applied properly.

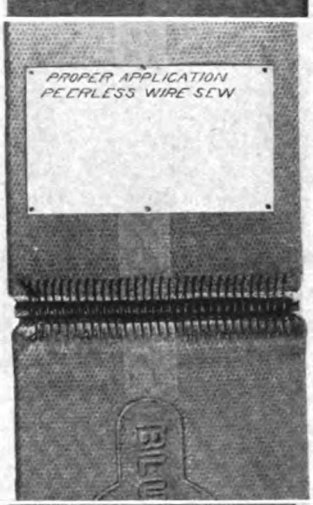




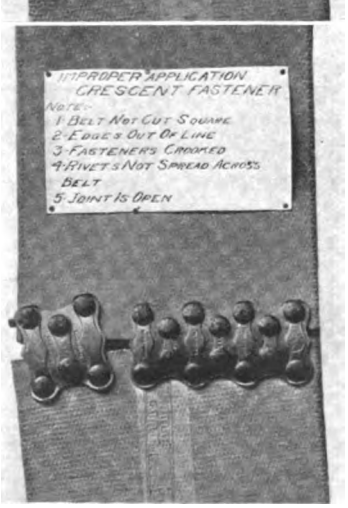


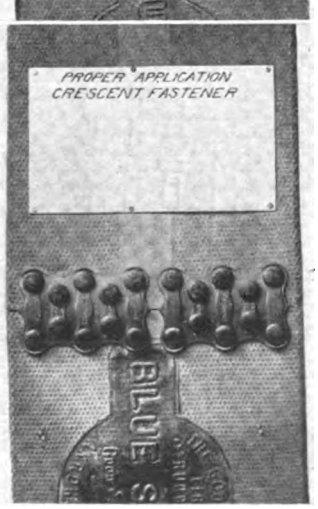












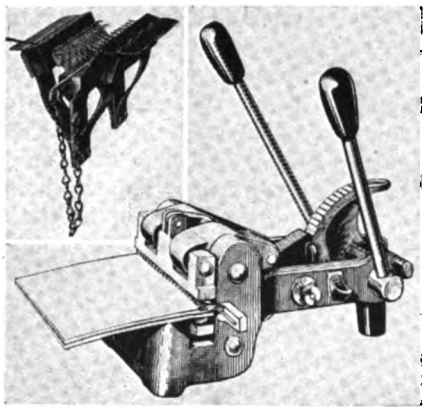


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the belt sufficiently to protect them from wear in passing over the pulleys. This also overcomes the "momentary slippage" reported in some belting tests. Accomplishing this requires sufficient power in the closing of the hooks and the proper diameter of wire.

Three types of rigid connections are also commonly used. These are: Steel lacings (which are in reality a staple which clinches across the end of the belt), hooks, and plates. When steel lacings are applied care must be taken to see that the ends are properly clinched or else they leave a dangerous hook point to catch the clothes of those working around the belt. These are very quickly applied by simply squaring the end of the belt, driving steel points in with a hammer and clinching the ends. They are hard to remove without cutting out a section of belt. This interferes somewhat if only a fraction of an inch of belt is desired to be cut out. If hooks or links are used on belts care must be exercised to see that they are also properly clinched.

Plates are used frequently, especially on conveyor belts, which do not have to pass over idlers, or where the pulley only comes in contact with one surface of the belt. These are commonly riveted on by either solid or split rivets; in some cases bolts are used. The greatest difficulty in connection with these is that for convenience the wrong size is often used. If a plate too small is used the holes are too near the end of the belt. If a plate too large is used, it does not operate satisfactorily over a small pulley. On crowned pulleys, the use of two or more narrow plates is recommended instead of a single wide plate.



Two handy tools for applying metallic flexible lacings to belts.

To lace a belt with rawhide requires considerable time and several devices have been developed for joining belts with some sort of mechanical fastener, so that the work can be done more quickly. The two devices shown make a hinged joint by clinching a loop of wire around each end of the belt. The two ends are then fastened together with a rawhide pin. The upper of these two devices fits in a bench vise and clinches the fastener by screwing up the vise. The other device stands on the bench. These illustrations are by courtesy of the Detroit Belt Lacer Company. Care must be taken to use the right size hook for the belt.

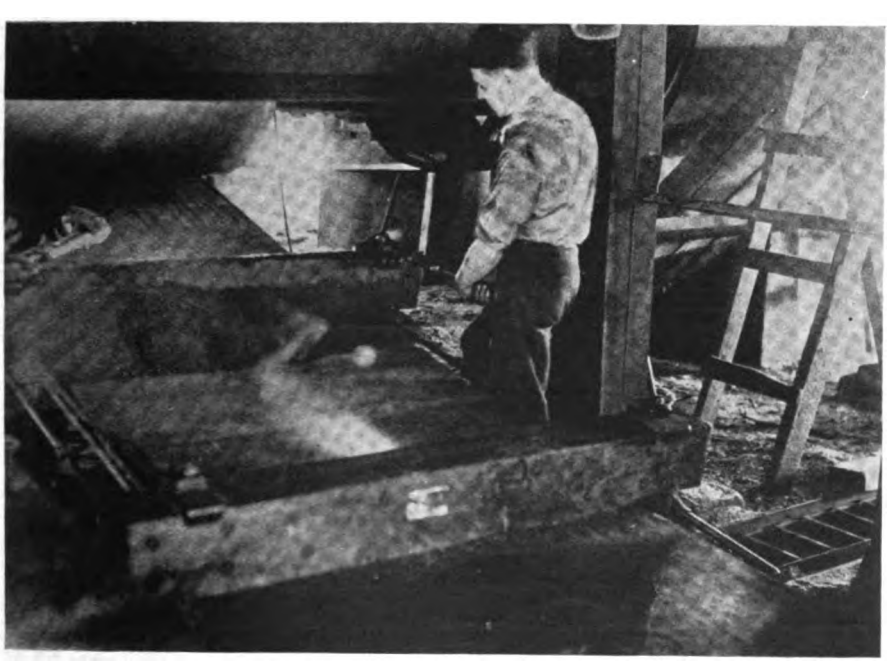
All of these various forms of metal fastenings are becoming quite common largely due to the ease of application. Practically all of them may be used on fabric belts but in any case the proper size should be used as one too small will pull out at the end or not dig far enough into the belt. Each manufacturer makes these in a variety of sizes, each best adapted to a specific type or size of belt. A large percentage of the difficulties incidental to their use is due to using the wrong size, not putting them on straight or not squaring the ends of the belt. Uneven ends throw the strain on a few hooks or rivets and the belts start to tear at this point. Failure to clinch properly has frequently caused injury but this can be prevented by exercising proper care in application.

Some Reasons Why Endless Belts Are Recommended

The Leather Belting Exchange, an association of leather belt manufacturers, has recommended that all leather belts be made endless whenever possible. It is probably best to do this in the factory if the belt can be installed endless at the plant. In many cases such as when placed over pulleys on lineshafts this is not convenient. Leather belts can, however, be cemented together at the ends after placing on the pulley. In such cases, as mentioned in the previous article, it is necessary to specify when ordering that it is to be made "with lap" and the exact length given. This, as stated, is best found by measuring with a steel tape. The belt manufacturer will allow for tension and lap. If canvas or fabric belts are to be made endless, that is without any joint, it must be done when the belt is made. However, these belts can be spliced when installed but do not have as smooth a joint as do cemented leather belts. How this joint can be made will be explained later in this article.

Some of the advantages of making belts endless are that they give smooth operation with idlers or over small pulleys, that there are no sharp ends to catch, and that they do not have to be re-laced due to the laces tearing or wearing out. Usually some method must be provided for taking up slack due to a belt stretching after it is in use.

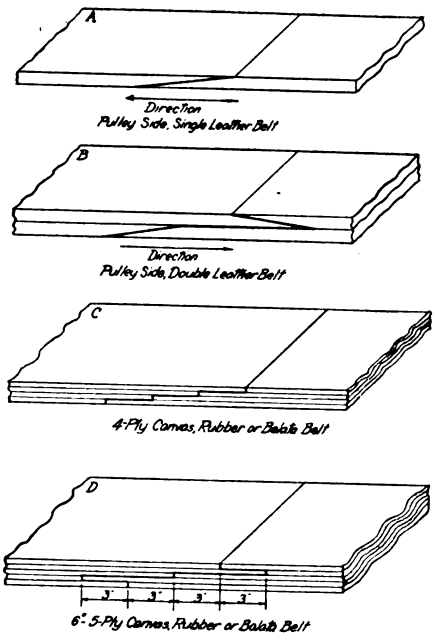
If a leather belt is to be cemented while on the pulleys belt clamps must be used. In any case it is advisable to cement all belts above 4-in. while on the pulleys. Smaller belts are often cemented off the pulleys. After the belt clamps are adjusted and tightened it is well, if the pulleys are far enough apart to permit the belt clamps to move, to rotate the pulleys



Making a 44-in., 3-ply leather belt endless.

This shows how belt clamps are applied when making a leather belt endless. It is recommended that they be used on all belts over 5 or 6 inches in width and they are always necessary when belts are joined while on the pulleys. This large leather belt was supplied by the Chicago Belting Company for a Pacific Coast saw mill.

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How joints are made when belts are made endless.

Leather belts can be cemented together at the joints and so made endless in the industrial plant. How the laps are laid out for cementing single and double leather belts is shown in *A* and *B* above. The point of the lap on the outside of the belt should not point in the direction of travel, otherwise the air would soon open the joint. How these joints are made is described in the text. Four- and five-ply canvas rubber or Balata belts may be spliced as shown in *C* and *D*. The first step in joining a fabric-base belt is to cut it down the sides along where the joint is to be made to separate the wrapped plies. The friction coating is next scraped from the top of the belt and the laps warmed with a red-hot iron, care being taken that the iron does not come into actual contact with the belt. The plies are next cut off to the proper length and the surface scraped to roughen the laps. Again warm the belt with a hot iron and apply a rubber belt cement. Many rubber belt cements are inflammable and should be kept away from any fire. After allowing to dry for about twenty minutes, warm the laps again until they become tacky and then stick together and place under a belt press. After putting under moderate pressure for about ten minutes, remove the belt from the press and allow it to cool. Joints should be strengthened by sewing or riveting, or stitching with rawhide. Cemented joints on leather belts when properly made need no reinforcing by rivets or sewing. It is always preferable, if possible, to have belts made endless by the manufacturer. This method of joining fabric base belts is given by R. & J. Dick Company, Inc., in some of their literature.

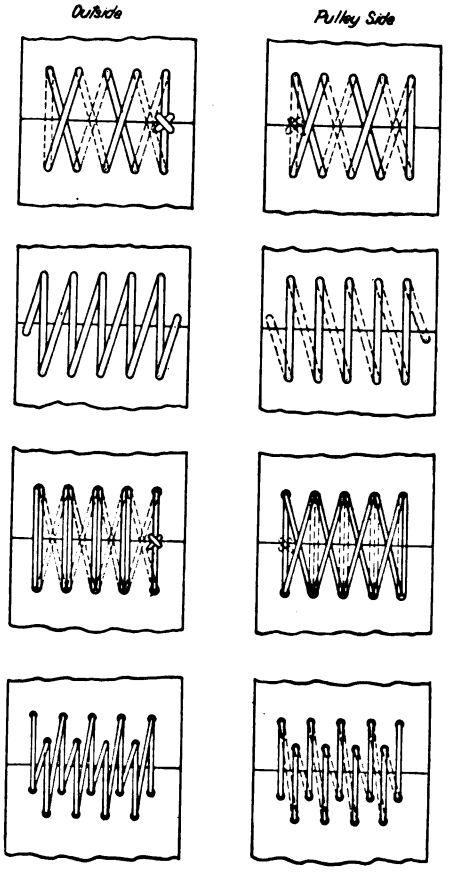
as far as possible in one direction and then back so that the belt clamp goes from one pulley to the next and back again. This permits of more even tension in the belt instead of putting it all in one side.

The Operations in Cementing a Leather Belt

The first step in making a belt endless is to measure the belt and get the proper allowances so as to give the correct tension. Some belt clamps have tension gages which indictate the tension on the belt.

The most common rule in determining the proper tension for a belt is to shorten the belt by ⅛-in. per foot in length below the exact length as indicated by a steel tape line. On cheaper grades of belt a little more, about ¼-in per foot in length, should be taken out. When the length is determined the next step is to make the proper allowance for the lap-joined edge, and then cut the ends square. Ordinarily an allowance of 4-in. for the scarfed or skived edges is made on belts up to 3 in. wide. This increases in steps equal to the increase in width of the belt. Double belts allow 6 in. for lap on belts up to 3 in. wide, 7 in. for 7-in. belts and an allowance equal to the width up to 18 in wide. Above this width only 18 in. are allowed.

The first step is to make the ends square. This is of the utmost importance in any method of joining belts. If the belt man does not have a square or if the belt is wavy, so that a square would not give a true square end, another method is frequently used by practical belt men. This consists of placing the two end pieces of the belt on top of each other with the sides parallel and the ends together, but with one end of one belt twisted so that the smooth side of one comes next to the grain side of the other. If the belt is cut through both thicknesses at the same time, when the ends are turned and put together the two ends will fit together so that the belt is exactly true even though the ends are not perfectly square. It may be well to put together and mark first to be sure that the ends are put together right before cutting. Be sure not to cut off the allowance for lap.



It is best to lay out the lap so that the point of the lap on the grain or outside of the belt does not go against the wind. If a small section at the point of the lap should open up, if the belt goes against the wind, it would soon open the joint and weaken it. A set of belt splicing tools is shown in one of the accompanying illustrations. Practically all belt manufacturers or supply houses keep and supply sets of tools similar to these. After the ends are squared they are skived or scarfed down with a belt plane and finished with a scraper. The surface is then sandpapered lightly to roughen it slightly and any grease spots, which might have gotten onto the surface to be cemented from the hands, are removed with gasoline or naphtha. If a belt is filled with grease or oil it should be cleaned before trying to cement, as oily belts seldom cement well. Methods of degreasing will be explained in the next instalment of this series. The cement should be applied according to the directions given by the manufacturer of the cement. Some of the belt cements are applied hot and others cold. If the belt is to be used in moist or steamy places a waterproof cement should be used.

After the cement is applied to the two edges of the belt by a brush and the ends joined the lap should be laid on a board and hammered lightly, working from the center to the edges to work out any air which may have gotten in the cement and between the two ends of the belt. It should then be put in a press and held under pressure until dry. Small belts are often hammered only. If the ends of a leather belt are cemented properly it *(Continued on page 256)*

Four good methods of lacing belts with rawhide.

One of the most important steps in joining any belt is to see that the ends are cut square. It is also essential that the holes be punched even and in a straight line and not too close to the end of the belt. It is usually best to have the rawhide lacing on the running side in contact with the pulley extend in a straight line lengthwise with the belt. These ways of lacing are recommended in some literature issued by the Chicago Belting Company. Many other ways also make reliable joints.

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Practical Details and Tables for

Laying Out Unequal Groupings of Coils

In Induction Motors Having from Four to Forty-Eight Coils Two or Three-Phase

THIS ARTICLE IS the third of a series on connecting induction motors which have equal or unequal coil grouping. Two previous articles have appeared, in the March and April issues of INDUSTRIAL ENGINEER. The present article deals with unequal grouping of coils and treats this subject in a manner somewhat different from that which has been used in the previous articles. It should give the reader a clearer insight into the possibilities of using unequal grouping and a better understanding of balance in a winding.

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company

THIS DISCUSSION tells of a method of figuring unequal grouping of coils which is different from the methods already described in the March and April issues of INDUSTRIAL ENGINEER. A study of the information presented will give a better understanding of the principles of unequal grouping. The basis of this discussion is an article by E. M. Tingley in the Electrical Review and Western Electrician, Jan. 23, 1915. Mr. Tingley tells how to determine whether a certain number of coils will give a balanced winding, either with equal grouping or unequal grouping. Then he gives tables showing where equal groupings may be used and where unequal groupings must be used. He describes also a method of determining how large and small groups are arranged in an unequal grouping.

In studying Mr. Tingley's discussion it will be noticed that there are two terms which he uses in a somewhat different manner from their usage in the previous discussions in this series. In the first place, he uses the term "number of slots". He states, however, that throughout his article the number of slots equal the number of coils. In the previous discussions the number of slots has not been mentioned. The data have always referred to the number of coils regardless of the number of coils per slot. The second point to remember regarding Mr. Tingley's discussion is that when he refers to a balanced winding he means one

Sixteen-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, TOP-TO-TOP, CHART R

Coils	Group Numbers																				No. Large Groups	No. Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32						
48	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1					16	16
54	1 2	2 2	1 2-1	2 2	2 1	2 2	1 1	2 2	1 2	2 2	2-1 1	2 2	2 1	2 2	1 1	2 2					22	10
60	1 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	1 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2					28	4
62	2-1 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	1 2	2 2	2 2	2 2	2 2-1	2 2	2 2	2 2					30	2
72	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2					8	24
80	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2						
84	2 3	3 3	2 2	3 3	3 2	3 3	2 2	3 3	2 3	3 3	2 2	3 3	3 2	3 3	2 2	3 3					20	12
86	2 3	3 3	2 3-1	3 3	3 2	3 3	2 2	3 3	3-1 3	3 3	2 2	3 3	3 2	3 3	2 2	3 3						
90	2 2	3 3	3 3	3 3	3-1 2	3 3	3 3	3 3	2 2	3 3	3 3	3 3	2 3-1	3 3	3 3	3 3					26	6
104	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3						
108	4 5	5 5	4 4	5 5	5 4	5 5	4 4	5 5	4 5	5 5	4 4	5 5	5 4	5 5	4 4	5 5						
120	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4					24	8
135	5 4	4 4	5-1 4	4 4	4 5	4 4	4 5-1	4 4	5 4	4 4	4 5-1	4 4	4 5	4 4	4 4	4 4					7	25
144	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4						
150	4 5	5 5	4 5-1	5 5	5 4	5 5	4 4	5 5	4 5	5 5	5-1 4	5 5	5 4	5 5	4 4	5 5					22	10
156	4 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5	4 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5						
168	6 6	5 5	5 5	5 5	6 6	5 5	5 5	5 5	6 6	5 5	5 5	5 5	6 6	5 5	5 5	5 5						
180	5 6	6 6	5 5	6 6	6 5	6 6	5 5	6 6	5 6	6 6	5 5	6 6	6 5	6 6	5 5	6 6						
216	6 6	7 7	7 7	7 7	6 6	7 7	7 7	7 7	6 6	7 7	7 7	7 7	6 6	7 7	7 7	7 7						
240	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8						

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absolutely in balance from the theoretical standpoint. There are many possible windings which are not absolutely balanced, but which give, however, practically perfect operating characteristics. These latter windings have been included in the previous discussions. The number of possible connections with certain numbers of coils is greatly increased if these latter windings are used. Mr. Tingley's article follows:

Two-Phase and Three-Phase Lap Windings in Unequal Groups

"The following method of grouping lap windings in unequal groups per phase per pole, for induction motors, alternating-current generators, and similar apparatus, has the advantage of largely increasing the number of combinations of slots, poles and phases that may be used, over those obtainable with equal

Table I — Balanced Two-Phase and Three-Phase Windings

Any number of slots which is a multiple of the number opposite the number of poles will give balanced windings.*

Poles.	Three-phase.	Two-phase.
2	3	4
4	3	8
6	9	4
8	3	16
10	3	4
12	9	8
14	3	4
16	3	32
18	27	4
20	3	8
22	3	4
24	9	16
26	3	4
28	3	8
30	9	4
32	3	64
34	3	4
36	27	8
38	3	4
40	3	16
42	9	4
44	3	8
46	3	4
48	9	32
50	3	4
52	3	8
54	81	4
56	3	16
58	3	4
60	9	8
62	3	4
64	3	128
66	9	4
68	3	8
70	3	4
72	27	16
74	3	4
76	3	8
78	9	4
80	3	32
82	3	4
84	9	8
86	3	4
88	3	16
90	27	4
92	3	8
94	3	4
96	9	64
98	3	4
100	3	8
102	9	4
104	3	16
106	3	4
108	81	8
110	3	4
112	3	32
114	9	4
116	3	8
118	3	4
120	9	16
122	3	4
124	3	8
126	27	4
128	3	256
130	3	4
132	9	8
134	3	4
136	3	16
138	9	4
140	3	8

*There are other numbers of slots, as shown in Tables IV and V and in the Main Table and the grouping charts accompanying this series, which may be used to give unequal groups satisfactory in practice though not absolutely balanced.

Sixteen-Pole Windings

UNEQUAL COIL GROUPING

THREE-PHASE, TOP-TO-TOP, CHART Y

Coils	No. Large Groups	No. Small Groups	Group Numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
54	6	42	2	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
60	12	36	2	1	2	1	1	1	1	1	2	2	1	1	2	1	1	2	1	1	2	1	1	1	1	1	1	1	2	1	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	2	2
62	14	34	2	1	2–1	1	2	1	1	1	2	2	1	1	2	1	1	2	1	1	2	1	1	1	1	1	2	1	2–1	1	2	1	1	2	2	2	1	1	2	1	1	2	1	1	2	1	1	2	2	2
72	24	24	2	1	2	1	1	1	2	1	2	1	1	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2
80	32	16	1	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	–1	2	2	1	2	2	1	2	2	1	2	2	2	2
84	36	12	1	2	2	2	1	2	2	2	1	2	2	1	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
86	38	10	2	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2–1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2
90	42	6	2	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2
104	8	40	2	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2
108			3	2	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3
120	39	9	3	2	3	2	2	2	3	2	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3
128			2	3	2	3	2	3	3	2	3	3	2	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3
135			3	2	3	2	3	2	3	3	3	3	2	3	3	3	3	3	2	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4
150	9	32	4	3	4	3	3	3	4	3	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4	3	3	4	4
156			3	3	4	3	4	3	4	3	4	4	3	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4
160	16	32	4	3	4	3	4	3	4	3	4	4	3	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4
168			4	3	4	3	4	3	4	3	4	4	3	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4
180	9	40	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	3	4	4	4	4
216			5	4	5	4	5	4	5	4	5	5	4	5	5	4	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5	4	5	5	5

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groups per phase per pole. While it may not be new, it is not generally known or used. The form in which it is herewith presented may be new. Several designing engineers have used such windings in special cases, but apparently without investigating all the possible combinations.

"The continuous or two-circuit retrogressive and progressive windings in which the number of slots is one more or less than a multiple of the number of pairs of poles are now seldom used, either as closed or continuous windings or as open windings, for the stators of induction motors or alternating-current generators. Such windings were used a few years ago in rotating-armature generators and they are now used

Table II—Possible Three-Phase Windings with Various Numbers of Slots

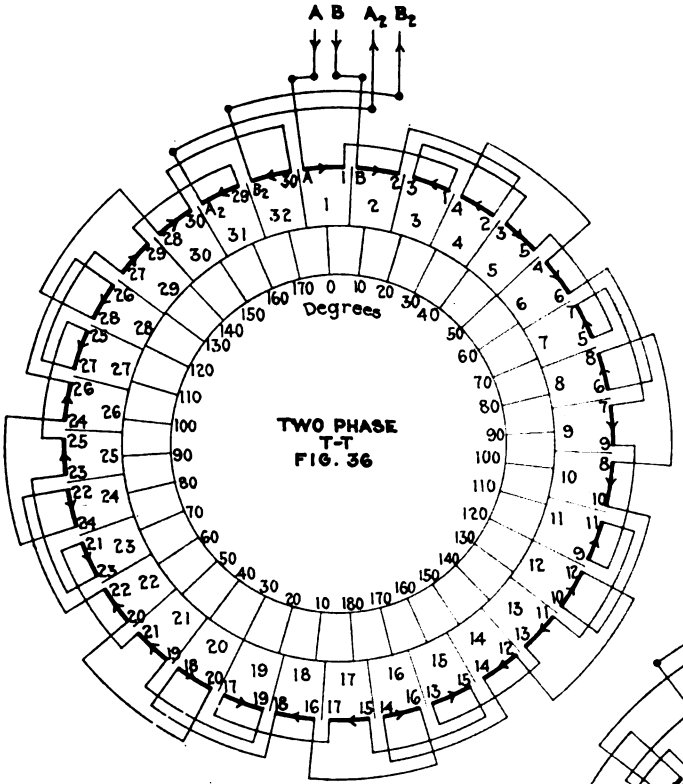
No. Coils	Number of Poles																							
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12†	=	=																						
15	★	0																						
18	=	★	=																					
21	★	0	•																					
24†	=	=	•	=																				
27	★	0	★	0																				
30	=	★	•	★	=																			
33	★	0	•	0	★																			
36†	=	=	=	★	0	=																		
39	★	0	•	0	0	•																		
42	=	★	•	★	★	•	=																	
45	★	0	★	0	★	★	★																	
48†	=	=	•	=	★	•	0	=																
51	★	0	•	0	0	•	★	★																
54	=	★	=	★	0	★	★	★	=															
57	★	0	•	0	★	•	0	0	•															
60†	=	=	•	★	=	•	★	★	•	=														
63	★	0	★	0	★	★	★	0	•	★														
66	=	★	•	★	0	•	★	★	•	★	=													
69	★	0	•	0	0	•	0	★	•	0	★													
72†	=	=	=	=	★	=	★	★	•	★	★	=												
75	★	0	•	0	★	•	★	★	•	★	★	•												
78	=	★	•	★	★	•	0	★	•	★	0	•	=											
81	★	0	★	0	0	★	★	0	★	0	★	★	★											
84†	=	=	•	★	0	•	=	★	•	★	★	•	★	=										
87	★	0	•	0	★	•	★	0	•	★	0	•	★	★										
90	=	★	=	★	=	★	0	★	•	★	★	★	0	★	=									
93	★	0	•	0	★	•	★	★	•	★	★	•	★	★	•									
96†	=	=	•	=	0	•	★	=	•	★	★	•	★	★	•	=								
99	★	0	★	0	0	★	0	★	•	0	★	★	★	0	★	★								
102	=	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	=							
105	★	0	•	0	★	•	★	0	•	★	★	•	0	★	•	★	★							
108†	=	=	=	★	★	=	★	★	=	★	★	★	★	★	★	★	★	=						
111	★	0	•	0	0	•	0	0	•	0	0	•	★	0	•	0	★	•						
114	=	★	•	★	0	•	★	★	•	★	★	•	★	★	•	★	★	•	=					
117	★	0	★	0	★	★	★	★	•	★	★	★	★	★	★	★	★	•	★					
120†	=	=	•	=	=	•	0	★	•	=	0	•	★	★	•	★	0	•	★	=				
123	★	0	•	0	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★				
126	=	★	=	★	0	★	=	★	•	★	★	★	★	★	★	★	★	•	★	★	=			
129	★	0	•	0	0	•	★	0	•	0	★	•	0	★	•	0	★	•	★	★	•			
132†	=	=	•	★	★	•	0	★	•	★	=	•	★	★	•	★	★	•	0	★	•	=		
135	★	0	★	0	★	★	★	0	★	★	★	★	★	★	★	★	0	★	★	★	★	★		
138	=	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	=	
141	★	0	•	0	0	•	0	★	•	0	★	•	★	0	•	★	★	•	★	0	•	★	★	
144†	=	=	=	=	0	=	★	=	•	★	0	=	0	★	★	★	★	•	★	★	★	★	★	=
147	★	0	•	0	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•
150	=	★	•	★	=	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•

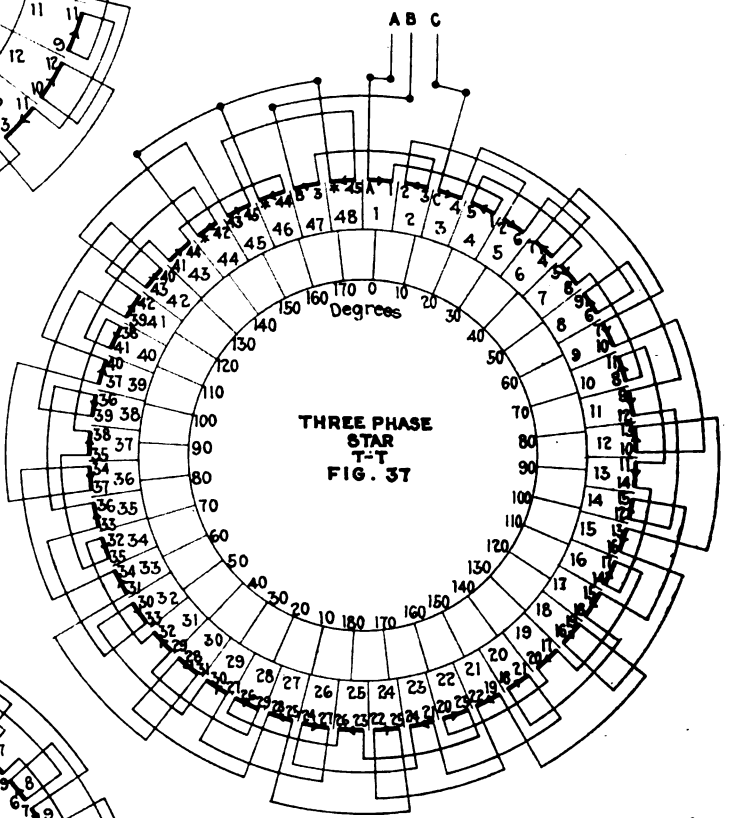
† Slots suitable for two phases also.
= Equal group windings.
★ Unequal group windings.
0 Unequal group windings for lap or two-circuit wave winding.
• Not perfectly balanced but satisfactory in practice for unequall y grouped lap windings.

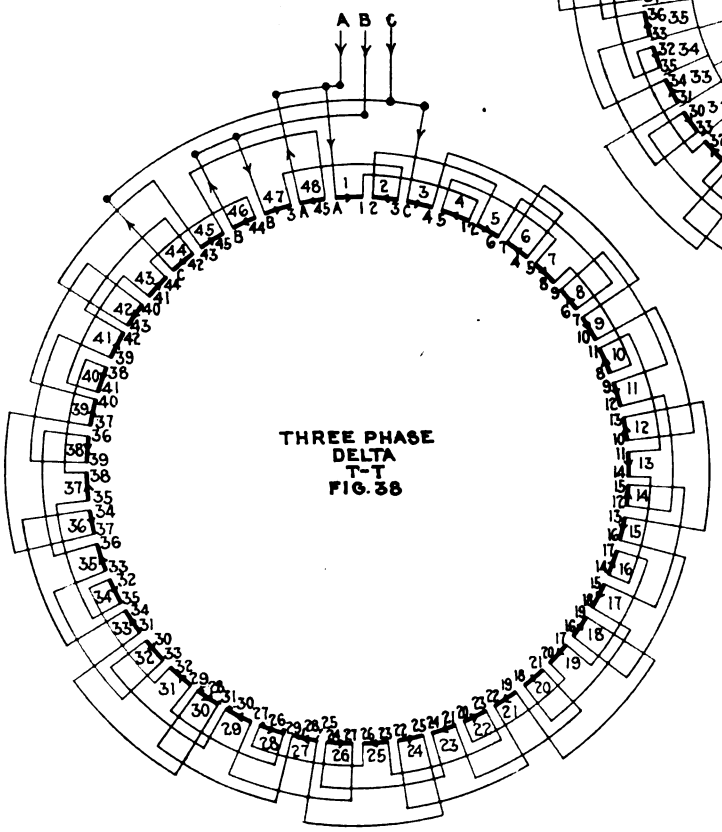
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Sixteen-Pole Windings

See Tables on page 246 and 247 Showing the Corresponding Groupings and Method of Connecting Ends of Groups.







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frequently in wound induction-motor rotors, partly on account of the wave form of end connectors and also for obtaining desired ratios between stator and rotor slots. To obtain balanced or symmetrical phases as regards current and voltage the number of coils per phase must be equal. Possibly such windings have not been used more frequently because it has been thought that the required number of slots for a particular case would answer only for that case, and also because acceptable combinations of slots and poles are very limited in number. With such windings in open connection it is immaterial whether the end connections are of the wave or of the lap form. In general the form of end connections that gives the

Table III—Possible Two-Phase Windings with Various Numbers of Slots

No. Coils	Number of Poles																						
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
4	=																							
8	=	=																						
12†	=	•	=																					
16	=	=	0	=																				
20	=	•	0	•	=																			
24†	=	=	=	•	0	=																		
28	=	•	0	•	★	•	=																	
32	=	=	0	=	★	★	★	=																
36†	=	•	=	•	0	•	0	•	=															
40	=	=	0	•	=	★	★	•	★	=														
44	=	•	0	•	0	•	★	•	0	•	=													
48†	=	=	=	=	★	=	0	•	★	★	★	=												
52	=	•	0	•	★	•	★	•	★	•	★	•	=											
56	=	=	0	•	0	★	=	•	★	★	0	•	★	=										
60†	=	•	=	•	=	•	★	•	★	•	★	•	★	•	=									
64	=	=	0	=	0	★	0	=	0	★	★	★	0	★	★	=								
68	=	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•	=							
72†	=	=	=	•	★	=	★	•	=	★	★	•	★	★	★	•	★	=						
76	=	•	0	•	0	•	0	•	★	•	0	•	★	•	0	•	★	•	=					
80	=	=	0	=	=	★	★	•	0	=	★	★	★	★	★	•	★	★	★	=				
84†	=	•	=	•	0	•	=	•	★	•	★	•	★	•	★	•	0	•	★	•	=			
88	=	=	0	•	★	★	★	•	★	★	=	•	★	★	★	•	★	★	★	•	★	=		
92	=	•	0	•	★	•	0	•	★	•	★	•	0	•	★	•	★	•	★	•	★	•	=	
96†	=	=	=	=	0	=	★	=	★	★	★	=	★	★	★	•	★	★	0	★	★	★	★	=
100	=	•	0	•	=	•	★	•	0	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•
104	=	=	0	•	0	★	0	•	★	★	★	•	=	★	0	•	★	★	★	•	0	★	★	•
108†	=	•	=	•	★	•	★	•	=	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•
112	=	=	0	=	★	★	=	•	★	★	★	★	★	=	★	•	★	★	★	★	★	★	★	•
116	=	•	0	•	0	•	★	•	0	•	★	•	0	•	★	•	★	•	★	•	★	•	0	•
120†	=	=	=	•	=	=	0	•	★	=	0	•	★	★	=	•	0	★	★	•	★	★	★	•
124	=	•	0	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•
128	=	=	0	=	★	★	★	=	★	★	★	★	★	★	★	=	★	★	★	★	★	★	★	★
132†	=	•	=	•	★	•	0	•	★	•	=	•	★	•	★	•	★	•	0	•	★	•	★	•
136	=	=	0	•	0	★	★	•	0	★	★	•	★	★	0	•	=	★	★	•	★	★	★	•
140	=	•	0	•	=	•	=	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•
144†	=	=	=	=	0	=	★	•	=	★	0	=	0	★	★	•	★	=	★	★	★	★	★	•
148	=	•	0	•	★	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•	0	•	★	•
152	=	=	0	•	★	★	★	•	0	★	★	•	★	★	★	•	0	★	=	•	★	★	★	•
156†	=	•	=	•	0	•	★	•	★	•	★	•	=	•	★	•	★	•	★	•	★	•	★	•
160	=	=	0	=	=	★	0	=	★	=	★	★	★	★	★	•	★	★	★	=	★	★	0	★
164	=	•	0	•	0	•	★	•	★	•	0	•	★	•	0	•	★	•	★	•	★	•	★	•
168†	=	=	=	•	★	=	=	•	★	★	★	•	0	=	★	•	★	★	★	•	=	★	★	•
172	=	•	0	•	★	•	★	•	0	•	★	•	★	•	★	•	★	•	0	•	★	•	★	•
176	=	=	0	=	0	★	0	•	★	★	=	★	★	★	★	•	★	★	★	★	★	=	★	•
180†	=	•	=	•	=	•	★	•	=	•	★	•	★	•	=	•	★	•	★	•	★	•	★	•
184	=	=	0	•	0	★	★	•	★	★	★	•	★	★	★	•	★	★	★	•	★	★	=	•
188	=	•	0	•	★	•	0	•	0	•	0	•	★	•	★	•	0	•	★	•	0	•	★	•
192†	=	=	=	=	★	=	★	=	★	★	★	=	★	★	★	=	★	★	★	★	★	★	★	=
196	=	•	0	•	0	•	=	•	★	•	★	•	0	•	0	•	★	•	★	•	★	•	★	•
200	=	=	0	•	=	★	★	•	★	=	★	•	★	★	★	•	★	★	★	•	★	★	★	•
204†	=	•	=	•	0	•	0	•	★	•	★	•	★	•	★	•	=	•	★	•	★	•	★	•

† Slots suitable for three phases also.
= Equal group windings.
★ Unequal group windings.
0 Unequal group windings for lap or two-circuit wave winding.
• Not perfectly balanced but satisfactory in practice for unequally grouped lap windings.

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Sixteen-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two Phase, Top-to-Top. See Fig. 36

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13
2 Parallel															A_2
4 Parallel			A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	
8 Parallel															
16 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A

Three-Phase Star, Top-to-Top. See Fig. 37

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24
2 Parallel																				*		*	B
4 Parallel								*		*	B	*	A		C								
8 Parallel		*		*	B	*	A		C					*		*	B	*	A		C		
16 Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*

Three-Phase Delta, Top-to-Top. See Fig 38

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24
2 Parallel																				C		B	B
4 Parallel								C		B	B	A	A		C								
8 Parallel		C		B	B	A	A		C					C		B	B	A	A		C		
16 Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C

Eighteen-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 39

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17
2 Parallel																	A_2
3 Parallel											A_2	B_2	A	B			17
6 Parallel					A_2	B_2	A	B									A_2
9 Parallel			A_2	B_2	A 5	B 6	A_2 5	B_2 6	A	B					A_2	B_2	A 17
18 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2

Three-Phase Star, Top-to-Top. See Fig. 40

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24
2 Parallel																							*		*	B
3 Parallel														*		*	B	*	A		C		24		26	24
6 Parallel					*		*	B	*	A		C											*		*	B
9 Parallel		*		*	B 6	*	A 8	* 6	C 10	* 8	B	* 10	A		C				*		*		B 24	*	A 26	* 24
18 Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B

Three-Phase Delta, Top-to-Top. See Fig. 41

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24
2 Parallel																							C		B	B
3 Parallel														C		B	B	A	A		C		24		26	24
6 Parallel					C		B	B	A	A		C											C		B	B
9 Parallel		C		B	B 6	A	A 8	C 6	C 10	B 8	B	A 10	A		C				C		B	B 24	A	A 26	C 24
18 Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B

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tion Motor Windings

——————Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Two-Phase (Continued)

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
16 14 B_2 B	15 17 A A_2	16 18 B B_2	19 17 A_2 A	20 18 B_2 B	19 21 A A_2	20 22 B B_2	23 21 A_2 A	24 22 B_2 B	23 25 A A_2	24 26 B B_2	27 25 A_2 A	28 26 B_2 B	27 29 A A_2	28 30 B B_2	A_2 29 A	B_2 30 B

Three-Phase Star (Continued)

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
25 22 * C	23 26 A * B	27 24 *	25 28 C *	29 26 * A	27 30 B *	31 28 * C	29 32 A *	33 30 * B	31 34 C *	35 32 * A	33 36 B *	37 34 * C	35 38 A *	39 36 * B	37 40 C *	41 38 * A	39 42 B *	43 40 * C	41 44 A *	* 42 B	43 45 C *	* 44 A	B 3 *	* 45 C

Three-Phase Delta (Continued)

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
25 22 A C	23 26 A C B	27 24 C B B	25 28 C B A	29 26 B A	27 30 B C	31 28 A C	29 32 A B	33 30 C B	31 34 C A	35 32 B A	33 36 B C	37 34 A C	35 38 A B	39 36 C B	37 40 C A	41 38 B A	39 42 B C	43 40 A C	41 44 A B	C 42 B	43 45 C A	B 44 A	B 3 A	A 45 C C

tion Motor Windings

——————Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Two-Phase (Continued)

18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
16 18 B_2 18 B B_2 18 A_2 B_2	19 17 A 17 A 17 B_2 A	20 18 B 18 B 18 A B	19 21 A_2 B A_2	20 22 B B_2	23 21 A_2 A B_2	24 22 B_2 B A	23 25 A B A_2	24 26 B B_2	27 25 A_2 A	28 26 B_2 B	27 29 A 29 A_2	28 30 B 30 B_2	31 29 A_2 29 A	32 30 B_2 30 B	31 33 A A_2	32 34 B B_2	A_2 33 A	B_2 34 B

Three-Phase Star (Continued)

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25 28 * 28 * C 28 *	29 26 A 26 A 26 B A	27 30 B *	31 28 C 28 C 28 A C	29 32 * * *	33 30 * B	31 34 C *	35 32 * * A	33 36 B *	37 34 * * C	35 38 A *	39 36 * B	37 40 C * *	41 38 * A	39 42 * B 42 * *	43 40 * C	41 44 * A 44 * *	45 42 B * 42 * B	43 46 * C 46 * *	47 44 A * 44 B A	45 48 B *	49 46 C * 46 A C	47 50 A *	* 48 B	49 51 C *	* 50 A	B 3 *	* 51 C

Three-Phase Delta (Continued)

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25 28 A 28 A C 28 A	29 26 A 26 A B 26 A	27 30 B C	31 28 C 28 C A 28 C	29 32 C A B	33 30 C B	31 34 B A	35 32 B A A	33 36 B C	37 34 A C C	35 38 A B	39 36 C B	37 40 C B A	41 38 B A	39 42 C B 42 C C	43 40 A C	41 44 B A 44 B B	45 42 B C 42 B B	43 46 A C 46 A A	47 44 A B 44 A A	45 48 B C	49 46 C A 46 C C	47 50 A B	C 48 B	49 51 C A	B 50 A	B 3 C	A 51 C

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best mechanical construction should be used. *We shall here assume that the number of coils is equal to the number of slots.*

"The point to be made, however, is that these unequally grouped windings will give an electrical performance similar to the equally grouped windings almost universally used.

"Now there is also a large number of other similar combinations of slots, poles and phases, having an unequal number of slots per phase per pole or a fractional number of slots per phase per pole, as have the two-circuit windings, that will give symmetrical or balanced lap windings in the open-circuit connections, but which may not be conveniently two-circuit connected with the wave-form end connectors, and will require the lap form of end connectors.

"The method of analysis for obtaining these group combinations for three phases and for two phases is as follows: "A little study with a simple circular diagram of poles and slots will show that three equally spaced slots will give three balanced phases, as regards voltage, with any number of pairs of poles not a multiple of three. The same is also true of any number of equally spaced slots which is a multiple of three. Therefore, any multiple of three slots will give three balanced phases with any number of pairs of poles not a multiple of three."

Three slots containing three coils will give two poles provided they are connected to give what is known as "consecutive poles." Ordinarily such a connection is not employed. Six coils (or six groups) are usually employed to give two poles. However, this fact does not affect the reasoning so far as balanced voltage is concerned.

"The minimum number of slots for three phases with any other number of poles is determined from the factors of that number of poles. Six poles may be considered as three two-pole machines in one and inasmuch as three slots is the minimum number for two poles, then nine slots or any multiple of nine slots will give balanced phases with six poles. Thirty poles is the same as three ten-pole machines in one; therefore any multiple of nine slots will give three balanced phases with thirty poles."

As already stated when introducing Mr. Tingley's article the reasoning in the preceding paragraph holds only for absolutely balanced windings. In practice the limiting conditions are not so narrow. In fact, any number of coils divisible by 3 will form a balanced series three-phase winding. It will be balanced so far as the number of coils in series per phase is concerned. It may not be possible with certain numbers of poles and coils to distribute the large groups in a perfectly even or symmetrical manner around the winding. However, if they are distributed in a fairly even arrangement the winding will operate satisfactorily. Mr. Tingley does not include such a winding under his

Eighteen-Pole Two-Phase Windings

UNEQUAL COIL GROUPING — TWO-PHASE, TOP-TO-TOP, CHART S

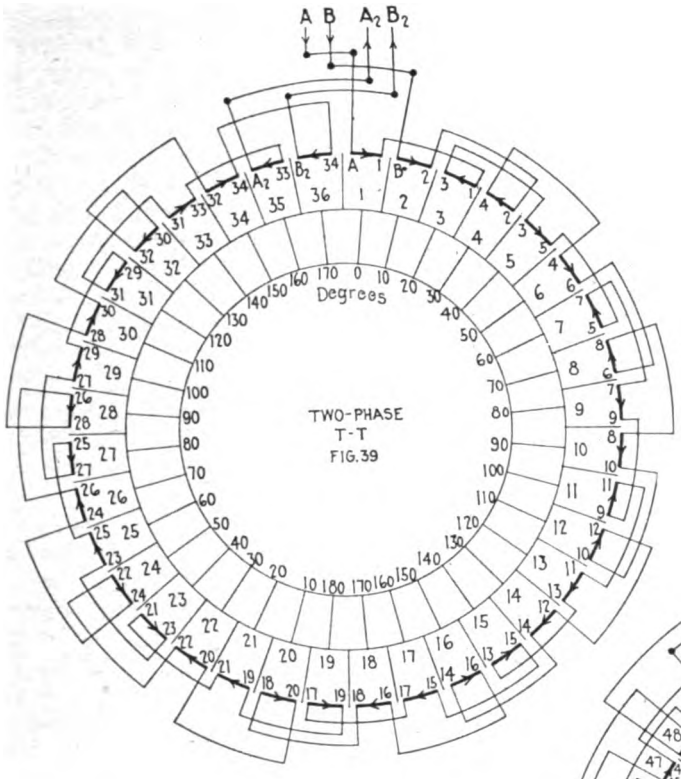
Groups	Group Numbers 1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	No. Large Groups	No. Small Groups
48	2 1	1 2	1 1	2 1	1 2	1 1	2 1	1 2	1 1	2 1	1 2	1 1	2 1	1 2	1 1	2 1	1 2	1 1	12	24
54	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	18	18
60	1 2	2 1	2 2	1 2	2 1	2 2	1 2	2 1	2 2	1 2	2 1	2 2	1 2	2 1	2 2	1 2	2 1	2 2	24	12
62	1 2	2 1	2 2	2-1 2	2 1	2 2	1 2	2 1	2 2	1 2	2 1	2 2	1 2	2 2-1	2 2	1 2	2 1	2 2	26	10
80	3 3	2 2	2 2	2 2	2 3	3 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 3	2 2	2 2	2 2	2 2	8	28
84	3 2	2 3	2 2	3 2	2 3	2 2	3 2	2 3	2 2	3 2	2 3	2 2	3 2	2 3	2 2	3 2	2 3	3 3	14	22
86	3 2	2 3	2 3-1	3 2	2 3	2 2	3 2	2 3	2 2	3 2	2 3	2 3-1	3 2	2 3	2 2	3 2	2 3	2 2	34	2
90	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	20	16
96	2 3	3 2	3 3	2 3	3 2	3 3	2 3	3 2	3 3	2 3	3 2	3 3	2 3	3 2	3 3	2 3	3 2	3 3	27	9
104	2 3k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3k 2	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	6	30
120	4 3	3 4	4 3	4 3	3 4	3 4	4 3	3 4	4 3	4 3	3 4	4 3	4 3	4 3	4 3	4 3	4 3	4 3		
128	3 3	4 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4		
135	3 4k	4 4	4 4	4 4	3 3	3 4-1	4 4	4 4	4 4	4k 3	4 4	4 4	4 4	3 3	3 3	4 4	4 4	4 4	16	20
150	5k 4	4 4	4 5	4 5	4 4	4 4	5 4	4 5	4 4	4 5k	5 4	4 4	5 4	4 5	4 4	5 4	4 5	4 4		
156	5 4	4 5	4 4	5 4	4 5	4 4	5 4	4 5	4 4	5 4	4 5	4 4	5 4	4 5	4 4	5 4	4 5	4 4		
160	5 5	4 4	4 4	5 5	5 5	4 4	5 5	4 4	4 4	5 5	4 4	4 4	5 5	5 5	4 4	5 5	4 4	4 4		
168	4 5	5 4	5 5	4 5	5 4	5 5	4 5	5 4	5 5	4 5	5 4	5 5	4 5	5 4	5 5	4 5	5 4	5 5		
240	6 7	7 6	7 7	6 7	7 6	7 7	6 7	7 6	7 7	6 7	7 6	7 7	6 7	7 6	7 7	6 7	7 6	7 7		

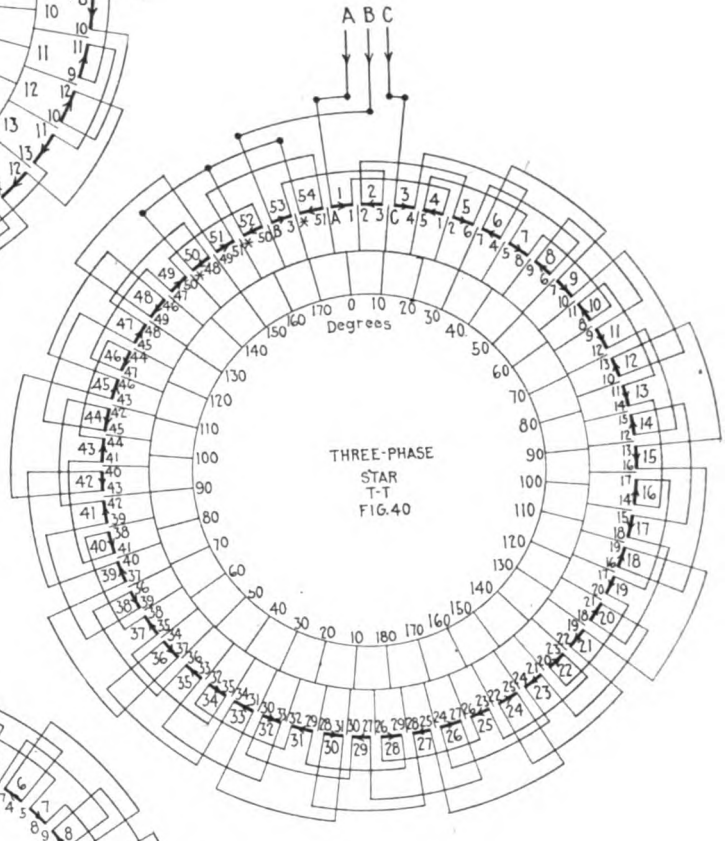
[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

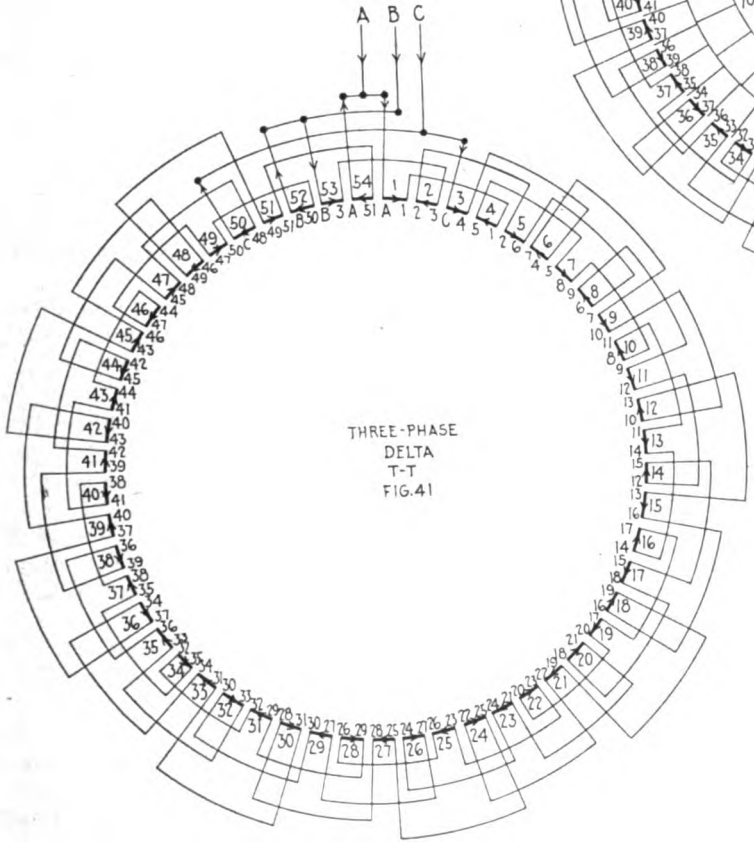
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Eighteen-Pole Windings

See Tables for Connecting Ends of Groups that appear on pages 246 and 247.







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Eighteen-Pole Three-Phase Windings

UNEQUAL COIL GROUPING — THREE-PHASE, TOP-TO-TOP, CHART Z

Coils	Group Numbers																																				No. Large Groups	No. Small Groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
60	2	1	—	1	—	—	1	—	2	1	—	—	1	—	—	1	2	1	1	—	—	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6	48
62	2	1	—	1	—	—	1	—	2	1	—	—	1	—	—	1	2	1	1	—	—	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2–1	1	1	1	1	8	46
72	2	1	—	1	2	1	1	—	1	2	—	—	1	2	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	2	1	2	1	1	2	1	1	2	1	1	1	1	1	18	36
80	2	1	—	2	1	—	2	1	2	1	2	—	2	1	2	1	1	1	2	1	2	1	2	1	1	2	1	1	2	1	1	2	2–1	1	2	1	2	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	26	28
84	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2k	2	1	2	1	1	2	1	1	2	1	2	1	2	1	2	2k	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2k	2	1	2	1	2	1	30	24
86	2–1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2k	2	1	2	2–1	1	2	1	1	2	1	2	1	2	1	2	2k	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2k	2	1	2	1	2	1	32	22
90	1	2	1	2	1	2	2	1	2	1	2	1	2	1	2	2	2	2	2	1	2	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	1	2	2	1	2	2	2	2	2	36	18
96	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	42	12
104	1	2	2	2	2	2	2	2	2–1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	50	4
120	3	2	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	2	2	2	2	2	3	2	2	3	2	2	2	2	3	2	2	2	3	2	2	3	2	2	3	2	2	3	2	12	42
128	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	3–1	2	3	2	3	2	3	2	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	20	34
135	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	2	2	3	2	3	2	3	2	3	2	3	3	2	3	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	27	27
144	2	3	2	3	2	3	3	2	3	3	2	3	2	3	2	3	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	36	18
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156	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	52	2
160	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3–1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
168	4	3	3	3	3	3	3	3	4	3	3	3	3	3	4	3	4	3	3	3	3	3	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	4	3	3	30	
180	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	4	3	4	3	3	4	3	3	3	4	3	4	3	3	4	3	3	4	3	24	
240	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4		

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

term "balanced windings." He includes only those windings in which the larger groups may be distributed in perfectly even or symmetrical manner. Such a winding has a theoretically perfect balance.

"In the same way it will be found that any multiple of four slots will give two balanced phases with any odd number of pairs of poles. The number of slots for the even numbers of pairs of poles is determined from the factors of the number of poles. For example, twelve poles may be considered as two six-pole machines in one, and as four slots is the minimum number for six poles, any multiple of eight slots will give two balanced phases with twelve poles."

The reasoning here is the same as that explained for a three-phase winding. It holds only for perfectly balanced windings. In practice any number of coils divisible by 2 will give a satisfactory two-phase series winding.

"Some of the above combinations will of course give a whole number of slots per phase per pole, or equally grouped windings. For quick inspection of all the possible combinations of slots and poles the accompanying tables for three phases and for two phases have been prepared. Such tables may be extended indefinitely as regards slots or poles.

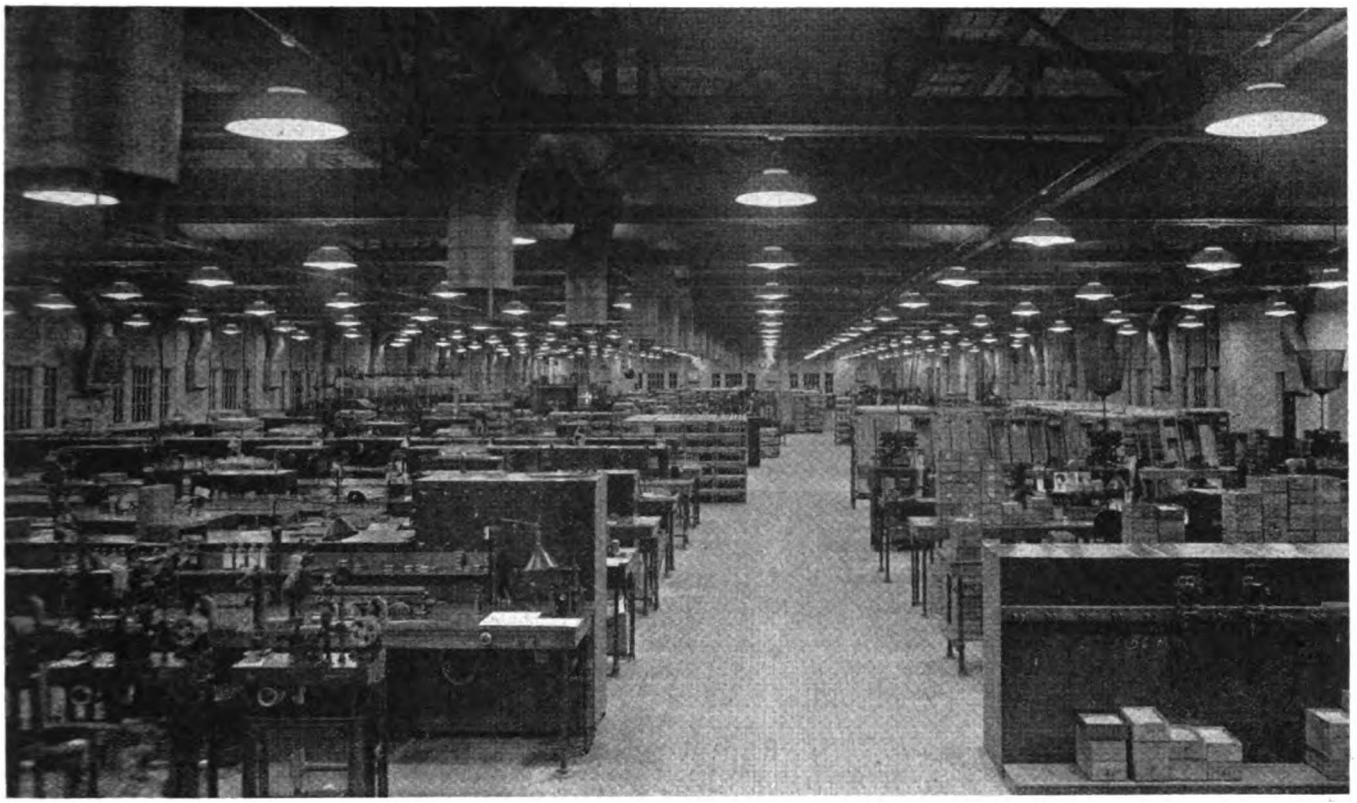
"Table No. I gives the minimum number of slots for three and for two phases for any number of poles up to 140.

"Table II shows all the possible three-phase balanced windings up to 48 poles and 150 slots. The character under the number of poles indicates the type of winding for the number of slots opposite.

"Table III gives the same data for balanced two-phase windings up to 48 poles and 204 slots.

"In all these windings the phases have, in a given case, equal numbers of coils. Where the number of coils per phase per pole is not equal, the average position of the coils compensates for this inequality and balances the phases electrically. Of course there is a practical lower limit to the number of slots per pole that may be used; say, one slot per phase per pole. The larger the number of slots the more uniform will be the armature reaction at the different poles, although in generators built with a small number of slots per phase per pole non-uniform armature reaction has not been apparent.

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Lighting units consisting of 200-watt clear Mazda C lamps in combination glass-and-steel reflectors give an average illumination of twelve foot-candles in this lamp factory. These units are spaced 10 ft. by 10 ft. 8 in. and are mounted 11 ft. above the floor.

Practical Advantages of

Flexibility in a Lighting System

By the Proper Placing of Outlets and Adequate Wiring and Switching

By JAMES M. KETCH and A. F. IRISH

Engineering Department, National Lamp Works of General Electric Company, Cleveland, Ohio

IT REQUIRES little more than a casual observation in the average industrial plant to see the need for a flexible lighting system. Flexibility as it is applied here, means that the lighting system should adequately meet not only the normal variations in the day's work but should also be able to care for possible changes in machine arrangement, kind of work carried on and the like, over a period of years. Based on the writers' own experience, it appears that too often the various operations in an industrial works are each classed as a special lighting problem, whereas in many cases one of the standard methods of lighting could be profitably applied. There is no question but that special applications of lighting to machines have brought forth some excellent examples of mechanical ingenuity but in such cases maximum flexibility is usually not obtained.

It should not be inferred from what has been said that there is any one set of rules which will give the answer to all shop lighting problems or which will give perfect flexibility in the lighting system. There are, however, a number of standard methods of lighting which if properly applied will undoubtedly afford the greatest practical flexibility in most cases. In fact, one of the best reasons for the popularity of general overhead systems of a fairly high foot-candle value, is their adaptability to a wide variation in working conditions.

Fundamentally there are five factors which contribute to the flexibility of a lighting system:

(1) The proper spacing of outlets so that regardless of the lamp wattage a uniform level of illumination may be obtained over the entire working area.

(2) An illumination of sufficiently high foot-candle value over the entire area sufficient to care for the most exacting work to be carried on.

Five Factors that Contribute Toward Flexibility of a Lighting System

1—The proper spacing of outlets so that regardless of the lamp wattage a uniform level of illumination may be obtained over the entire working area.

2—An illumination of sufficiently high foot-candle value over the entire area sufficient to care for the most exacting work to be carried on.

3—Sufficient copper to permit more light or wattage to be obtained when needed.

4—A switching arrangement that will economically provide light at the desired time and place.

5—The selection of a reflector that will allow for a future change in lamp size and wattage.

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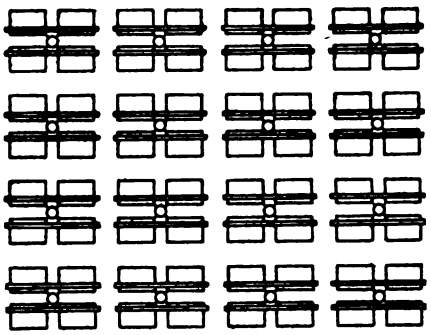


Fig. 1—One lighting unit is used in the center of each group of four looms. With looms removed, a good general overhead system remains.

(3) Sufficient copper to permit more light or wattage to be obtained when needed.
(4) A switching arrangement that will economically provide light at the desired time and place.
(5) The selection of a reflector that will allow for a possible future change in lamp size and wattage.

Light Distribution for Flexibility of Operations

General Lighting—As already suggested, general overhead lighting with the proper spacing of outlets permits of freedom in the arrangement of machines and processes. It was during the rush of war activities, when all industrial plants were adapting themselves to the new and larger demands suddenly placed upon them, that the value and flexibility of general lighting became more widely appreciated. Where workmen are obliged to move about from one machine to another or to bench or assembly work, the ordinary losses of time are undoubtedly reduced to a minimum under high-intensity, general lighting systems.

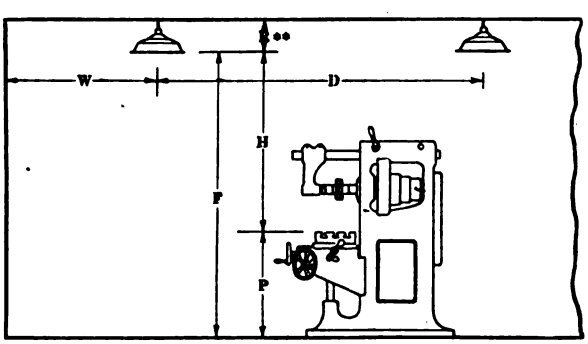
If the room under consideration can be successfully lighted by natural daylight, it is usually considered practicable to adequately light the work space by a well-designed general lighting system. A distinct advantage of artificial lighting is that the illumination can be made uniform throughout the entire work area. In this respect it is possible to simulate outdoor daylight conditions.

Since the success of a general lighting system depends upon the units being properly spaced and mounted, it will not be out of place here to suggest spacing and mounting ratios ordinarily employed for direct-lighting units. The spacing ratios in Table I can be worked either way; that is, the spacing of the outlets may be determined by the bay sizes or machine arrangement, in which case the units themselves should be hung not lower than the minimum height shown in Table I. In other cases the mounting height is limited by the height of the ceiling, in which case the maximum spacing as shown in Table I may be followed.

In column 5 of Table I is given the maximum allowable distance between the walls and the first row of units which applies in cases where there are work benches, machines or desks next to the wall. It is suggested that this spacing be used if there seems to be any possibility at all later, of work being carried on next to the wall. In locations where aisles or storage spaces are next to the wall, column 4 is used. Where the spacing and mounting height values given in this table are followed a fairly even illumination will be obtained which allows consider-

TABLE I—Spacing Distances and Mounting Heights for Direct Lighting Units

Mounting Height of Unit		Permissible Distance Between Outlets	Permissible Distance Between Outlets and Sidewalls	
Above Plane of Work (H)	Above Floor* (F)	(D)	In Usual Locations Where Aisles & Storage Are Next to Wall (W)	Where Work Benches are Next to Wall (W)
4	6½	6	3	2
5	7½	7½	3½	2½
6	8½	9	4½	3
7	9½	10½	5	3½
8	10½	12	6	4
9	11½	13½	6½	4½
10	12½	15	7½	5
11	13½	16½	8	5½
12	14½	18	9	6
13	15½	19½	9½	6½
14	16½	21	10½	7
15	17½	22½	11	7½
16	18½	24	12	8
18	20½	27	13½	9
20	22½	30	15	10
22	24½	33	16½	11
24	26½	36	18	12
27	29½	40½	20	13½
30	32½	45	22½	15
35	37½	52½	26	17½
40	42½	60	30	20



*Plane of work (P) assumed to be 2½ feet above floor. When the plane of work is higher or lower than 2½ feet above floor, neglect column (F) and work from column (H).
**Minimum allowance for (R) usually 1 foot.

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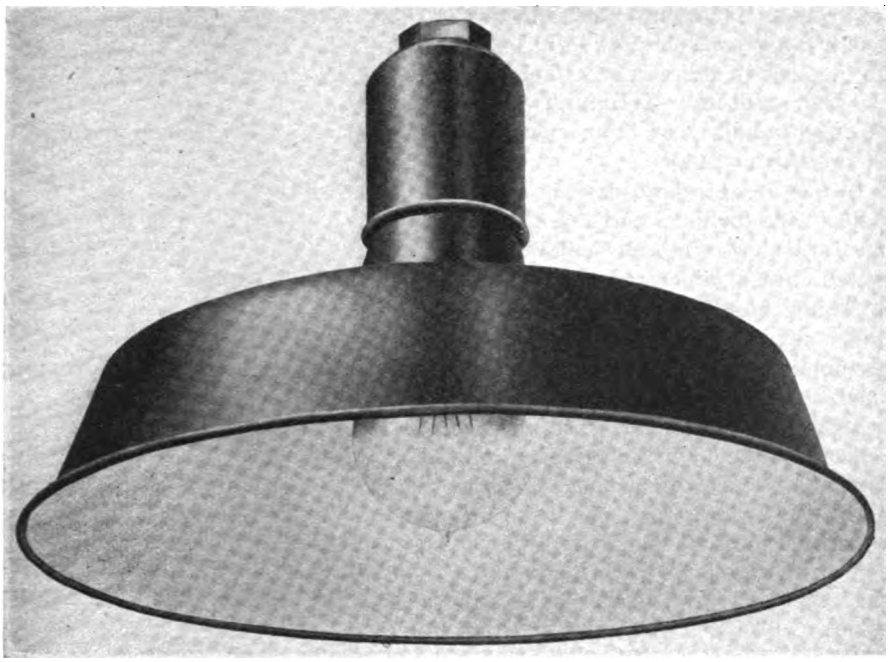


Fig. 2—The RLM-dome-bowl-enameled-lamp combination is suitable for a wide variety of industrial operations.

able latitude in the arrangement of machines and shop operations.

The dome type reflector, such as the RLM Standard Dome shown in Fig. 2, is ordinarily recommended for general lighting systems where the reflectors are around 9 ft. or more above the floor. The efficiency of these reflectors is good and when used with the bowl-enameled Mazda C lamp, the glare is minimized so as to be within practical limits. The shielding angle is such as to insure eye protection at ordinary mounting heights. However, where the reflectors are used at heights less than 8 to 10 feet above the floor, it is probably better practice to use the deep bowl type reflector which has a large shielding angle at a slight sacrifice of efficiency.

Group Lighting—The arrangement of machinery and manufacturing processes in some industries prohibits the use of general lighting in its broadest sense. These industries are the ones for which even natural daylight is considered deficient, not as to the amount of light but rather as to the direction of light to the work. Some of the typical industries of this class are shoe and leather goods manufacturing, the press rooms and composing rooms of many printing plants, and in general the textile industries. In all of these the direction of light to the work is fully as important as the amount of light on the work. The arrangement of outlets in a group system is suggested by the name; that is, the units or rows of units are grouped with respect to machines or rows of machines rather than with respect to the bay arrangement or building dimensions.

The greatest flexibility in a system of this kind is obtained where the lamps and reflectors are so spaced and mounted that a good general lighting system is left in case the group-lighted machines are replaced by machines of a different kind. For example, the system shown in Fig. 1 was designed for lighting groups of weave looms, but the units are so spaced and mounted that the effect of a very good general lighting system is obtained. With the looms removed it would be possible to substitute any one of the many manufacturing processes for which general lighting is desirable.

For installations where little or nothing is known about the arrangement of machines or benches to be placed in a room, it will be found advantageous to put the outlets on a closer spacing than the maximum allowable. It is then possible to tap into these outlets and place the reflectors in a semi-permanent position where they may be needed for a particular purpose. An example of this is found in the average printing plant composing room where each type bench and imposing stone should be lighted by at least one lighting unit directly overhead. Obviously, it would be foolish to set the outlets for such a system permanently in a concrete slab ceiling, especially as it is common practice in many composing rooms to move the type cabinets from time to time as other equipment is added. The semi-permanent reflector mounting device shown in Fig. 7 is easily tapped into a convenient outlet and has been successfully used for such requirements.

Local and General Lighting—Unquestionably local lighting has a legitimate application in some indus-

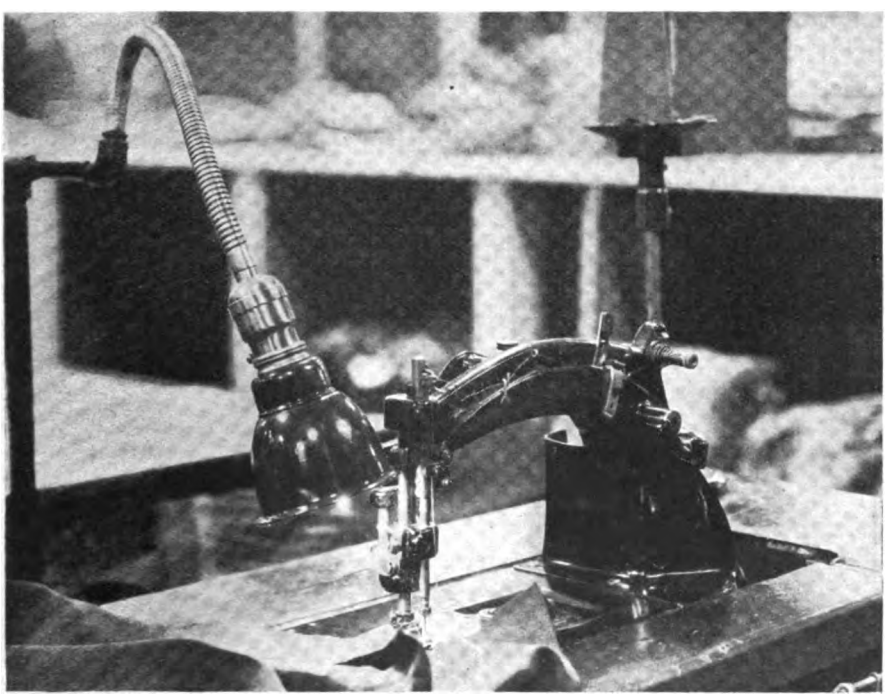


Fig. 3—A typical local lighting installation with deep bowl reflector and adjustable arm. This installation is supplemented by general overhead lighting of 9 foot-candles. The illumination at the needle is over 40 foot-candles.

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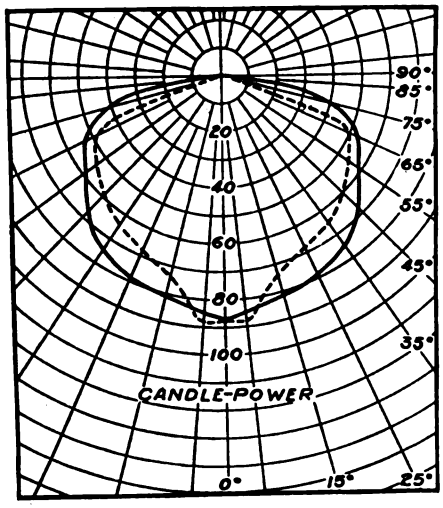


Fig. 4—Two distribution curves taken from the same reflector. The broken-line curve, obtained with the lamp filament just 1⅛ in. too high in the reflector, gives a reflector efficiency of 58 per cent. The solid-line curve, taken with the lamp filament in correct position, gives a reflector efficiency of 76 per cent.

tries. Typical examples are found in the lighting of sewing machines and automatic screw machines where the work is fine or dark and where as much as 50 foot-candles over a limited area may be necessary. However, even though a local light will take care of the work immediately at hand, a general overhead system giving say 6 or 8 foot-candles over the entire work area will be found economically good in the work of the entire department. Nothing is more disconcerting than trying to work when the lighting conditions force the eyes to be continually accommodating themselves to areas of high and low brightness. Here, the general lighting system has the additional advantage of flexibility, for if the locally lighted machines are removed, a good system of lighting still remains.

The type of reflector best adapted to local lighting is the small porcelain-enameled steel deep bowl shown in Fig. 3. It has a large shielding angle which is sufficient to protect the eyes when used in the normal position. Deep bowl reflectors with a recessed groove at the bottom which holds a glass plate in position so as to protect the lamp and reflecting surface, are available for local lighting use where there is any likelihood of the reflector becoming dirty through handling or from splashing oil or cutting fluid.

In most cases an adjustable device is desirable for local lighting, that is, one by which light can easily be directed into a hollow cylinder which is being bored or under the tool holder of a cutting machine. Where possible the device should be fastened firmly to the machine or a nearby wall. The arm holding the reflector should have flexible joints so that the reflector may be conveniently turned in any position and when turned will be rigidly held. The arm should be rigid enough so that the reflector will not have any serious vibration when the machine is working as the life of the lamp would be thereby shortened. Where it is impossible to eliminate all vibration the Mazda Mill-Type lamp is suggested. A small amount of efficiency is sacrificed to ruggedness in this type of lamp.

Wiring Capacity and Switching Arrangement

While it is important that proper lamps, reflectors, and outlet arrangements are used in the lighting system, the test of its flexibility is quite as often found in the wiring and switching.

It is not surprising that those who were installing lighting systems ten years ago did not anticipate the tremendous strides that illumination values have taken since then. The unfortunate outcome has been that lighting circuits in many plants are today far overloaded as larger and larger lamps are used to satisfy the natural desire for more and better illumination. In the textile industry it is now common practice to use a 200-watt lamp for the lighting of a group of four looms where ten years ago the 40-watt lamp was considered sufficient. Where colored or dyed materials are being worked there is an increasing tendency to replace clear lamps with Mazda Daylight lamps which require about 30 per cent more wattage for a given level of illumination. The result in many cases has been that because of overloaded circuits, lamps are being burned under voltage with decreased candlepower. This is uneconomical since a lamp burning 5 per cent under voltage has decreased 17 per

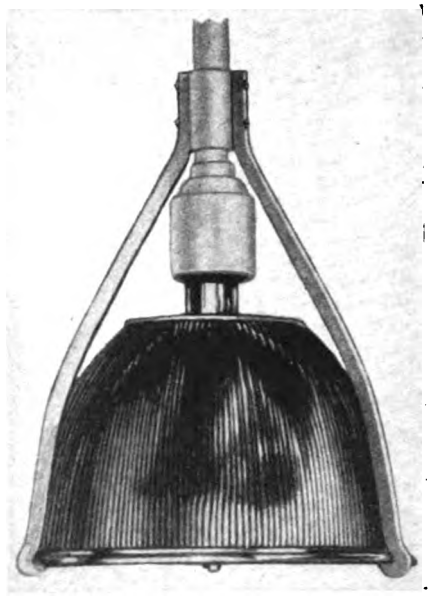


Fig. 5—This reflector is adjustable for lamps of different sizes but with the same base.

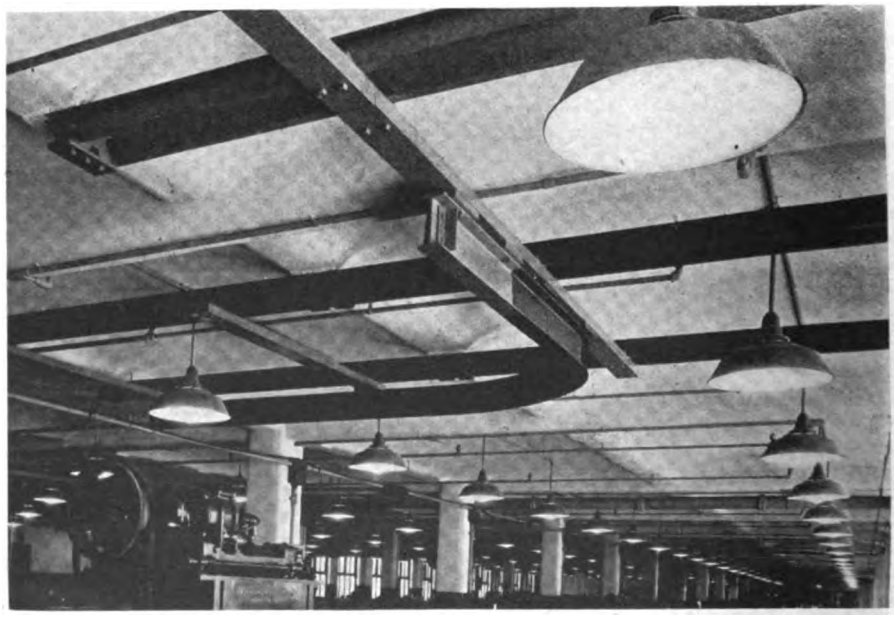
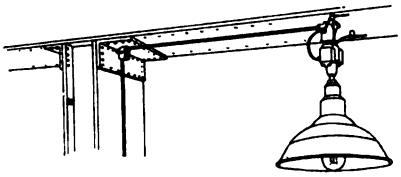


Fig. 6—A good lighting installation in a machine shop.

The lighting units consist of 300-watt Mazda C lamps in 20-in. combination glass-and-steel reflectors spaced on 10-ft. centers and give an illumination of about 20 ft.-candles. Small slots around the holder allow a certain amount of light to reach the ceiling. A glass globe within, and extending below the bottom of the reflector, cuts down the glare and also reflects light in the horizontal plane.

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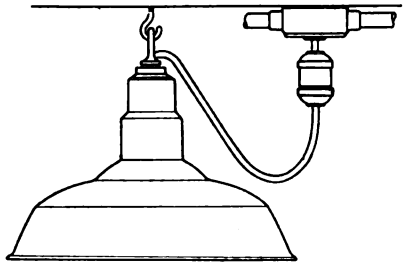


Fig. 7—Two suggestions for suspending industrial lighting units for flexibility in mounting and the ease of cleaning.

cent in light and has decreased only 8 per cent in wattage. So it is important in installing wiring today that the needs of the coming years be anticipated as far as possible. Table III shows that in many factories, natural daylight foot-candle values of from 20 to 35 are fairly common. The practice in several important industries today indicates that we are gradually moving toward similar values in artificial lighting.

Switching Groups—The answer to the switching problem usually lies in neither of the extremes commonly found; that is, all the units of a work area controlled by one switch, or an individual switch for each unit. Group switching properly applied will usually be satisfactory.

For example, in long, narrow buildings in which the machines are grouped in rows lengthwise of the building, the greatest flexibility is obtained if the lighting units are switched in groups or rows lengthwise of the building. Fading daylight can then be compensated for by turning on rows of units in the center of the room, and then gradually moving outward as the daylight recedes. In very large buildings or buildings which are nearly square, it is a good practice to switch the units in groups of two or four with the idea that four units will supply almost as much light to a man working in the center of the four as if the entire system were turned on. The arrangement of machines and windows will indicate whether the group should be in the form of a square or in a row.

TABLE II — Illumination Obtained from Several Sizes of Lamps Used in the Same Reflector (Fig. 8) with 12 ft. x 12 ft. Spacing — Average Factory Conditions.

Lamp Wattage	Foot-Candles of Illumination
500	24
300	13
200	8
150	5½
100	3½

Interchangeability of Lamps in Reflectors

The usual industrial reflector is of the dome type, is open at the bottom and is direct lighting, throwing the major portion of the light below the horizontal. Each size of reflector is designed for a particular shielding angle, efficiency and distribution of light only when the filament is in a certain position in the reflector. If the filament position is too low in the reflector the bright light source will be exposed to the eyes. If the filament position is too high, the reflector efficiency will be low. Photometric curves showing this condition are illustrated in Fig. 4.

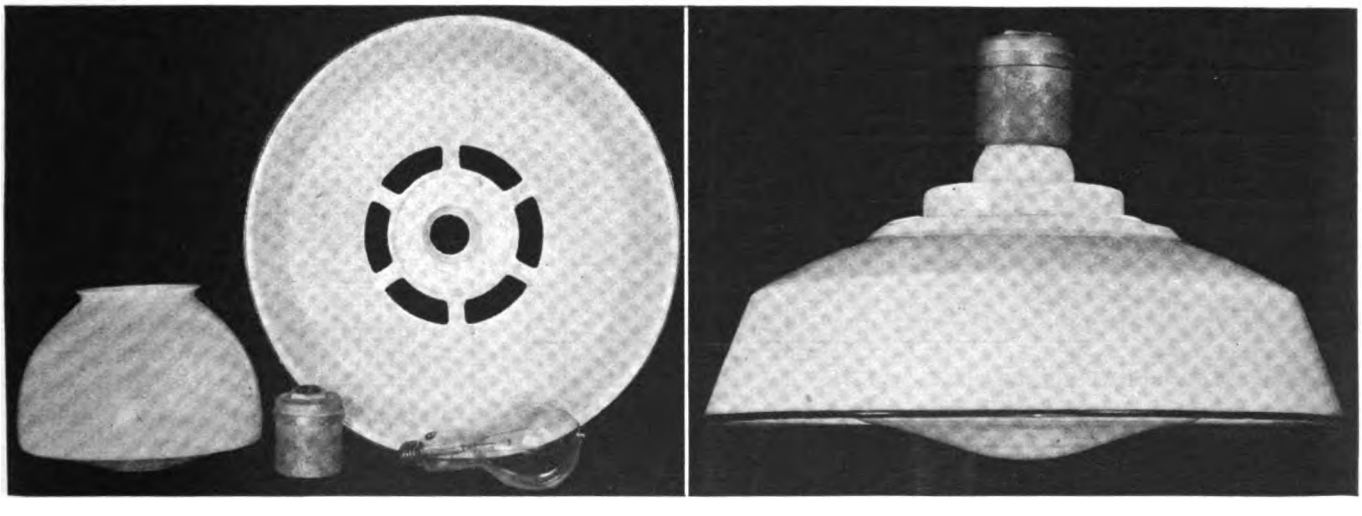
There are only a few sizes of lamps which have the same light-center-length and may be interchanged in open type reflectors with a resulting illumination proportional to the light output of the lamp. Of these the 100 and 150-watt, the 300 and 500-watt, and the 750 and 1000-watt lamps may be interchanged with no change in light distribution or reflector efficiency.

In one reflector it is possible to interchange lamps which have the same size of base by merely adjusting the position of the reflector so that the filament bears the same relation to the reflector in each case. This is the prismatic reflector shown in Fig. 5. Marks on the stem indicate the position of the supporting collar to be used for the various sizes of lamps.

In local lighting reflectors it is possible to use the short light-center length Mill-Type lamp in reflectors designed for 50-watt vacuum lamps by the use of a regular 1⅜ inch socket extension, which brings the shorter light-center of the mill-type lamp into the correct position.

A new reflector (Fig. 8) has been recently designed, and is now commercially available, in which it is possible to interchange certain lamps without materially affecting the light distribution or efficiency. This reflector was designed through the co-operation of the steel and glass reflector manufacturers with the engineers of the lamp companies. It

Fig. 8—A combination glass and steel industrial reflector which facilitates interchangeability of the lamps. An installation is shown on page 251.



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is possible to use the 200-watt, 150-watt or 100-watt lamp with a socket adapter in the reflector designed for 300 and 500-watt Mazda C lamps. The illumination in each case is, of course, in proportion to the light output of the lamps. That is, a 500-watt lamp in the reflector gives approximately seven times the illumination obtained with a 100-watt lamp in the same unit. This reflector can be used to advantage in many plants where the nature of the work is frequently changed, requiring more or less light. A good installation of this unit is shown in the photograph on page 251.

Table II shows the average maintained illumination which can be obtained from these reflectors on a 12 ft. x 12 ft. spacing in the usual factory by interchanging the lamps. If the illumination for a certain area was originally designed to be 13 foot candles with 300-watt lamps for a grinding operation, a 100-watt lamp giving 3½ foot-candles could easily be substituted should the space be turned over to rough assembly or storage purposes.

TABLE III—Working Levels of Daylight Illumination in Foot-Candles * *

Factory Products	Foot-Candles	Grade of Work		
		A	B	C
Engine lathes	Horizontal	10	7	3
	Vertical, Min.—Max.	6—15	2—15	0.5—9
Automatic engine lathes	Horizontal	14	12	10
	Vertical, Min.—Max.	2—30	2—30	1—15
Machined forging	Horizontal		6	5
	Vertical, Min.—Max.		2—15	1—10
Special machinery	Horizontal	10	7	
	Vertical, Min.—Max.	4—20	3—15	
Lamps	Horizontal	10	9	
	Vertical, Min.—Max.	5—16	11—15	
Vacuum cleaners	Horizontal	17	11	
	Vertical, Min.—Max.	7—25	3—20	
Automobiles	Horizontal	5	5	5
	Vertical, Min.—Max.	2—11	2—8	3—11
Automobiles*	Horizontal	10	3	5
	Vertical, Min.—Max.	6—12	1—3	4—5
Storage batteries	Horizontal		5	3
	Vertical, Min.—Max.		1—6	0.5—5
Machine tools and patterns	Horizontal	6	9	
	Vertical, Min.—Max.	2—16	3—35	
Sheet iron equipment	Horizontal	10	5	8
	Vertical, Min.—Max.	1—20	1—12	2—15
Machine gears	Horizontal	7	8	5
	Vertical, Min.—Max.	3—16	5—18	1—15
Hardware	Horizontal	10	10	4
	Vertical, Min.—Max.	1—20	1—20	0.5—12
Printing machinery	Horizontal		5	3
	Vertical, Min.—Max.		1—15	0.5—5
Sewing machines	Horizontal		4	2
	Vertical, Min.—Max.		1—8	2—5
Cloth bags	Horizontal		5	7
	Vertical, Min.—Max.		3—10	3—10
Clothing	Horizontal	10	4	
	Vertical, Min.—Max.	10—20	7—15	
Furniture	Horizontal	5	5	
	Vertical, Min.—Max.	3—20	0.5—12	
Average	Horizontal	10	7	5
	Vertical, Min.—Max.	4—18	3—15	1.5—10

**These values are a summary of several hundred readings made to determine the level of daylight illumination in a number of representative manufacturing plants.

*Saw tooth roof.

Servicing Industrial Transmission Belts

(Continued from page 240)

is not necessary to rivet them, as rivets only decrease the strength of the belt by taking away some of the cross-section area, and also make a stiff place when going over small pulleys. If the joint does not stick it is usually because it has not been applied properly or the belt is too full of oil. How single and double leather belts are cut and joined is shown in an accompanying illustration.

How Fabric Belts May Be Made Endless

Fabric belts, solid woven cotton and camel's-hair belts excepted, can be made endless at industrial plants when applied, but not so smooth a joint is obtained as with cemented leather belts or if the fabric belts are made endless at the factory. Two sketches reproduced in this article show how a 4- and 5-ply canvas, rubber or Balata belt may be joined. The method of doing this is described in the caption under the illustration and will not be repeated here. The manufacturers of these belts, however, recommend that after fabric-base belts are cemented together, they be stitched or riveted so as to strengthen them, and also to hold down the plies. After this is done it is difficult, however, to open the belt and take out a very short length if it is desired to again shorten them. A leather belt, however, may be opened and as small an amount as a fraction of an inch may be taken out and the belt re-cemented.

Wherever possible, as stated before, it is best to make all leather belts endless. A comparison of an endless belt and a similar belt joined by one of the best metallic fasteners, properly applied, showed a decreased capacity of about 15 per cent for the one with the fastener. Where the load is not too heavy or the belt operated at *(Continued on page 277)*

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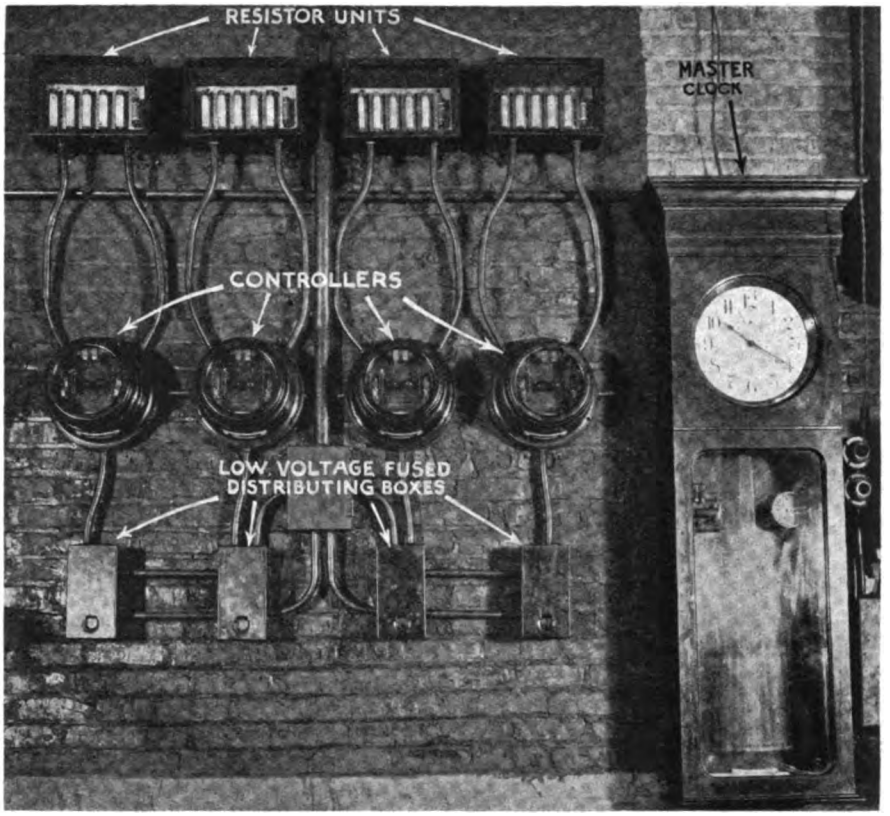
Operating Details of

Low-Voltage D.C. Control

Which has Insured Reliability and Low Operating Cost for Signal Systems

By PAUL F. CLAUSEN

Chief Engineer, Lyon & Healy Inc., Chicago, Ill.



This shows four of the eleven controllers which supply low-voltage current for operating the extensive sprinkler and fire alarm, electric-clock and signal service systems described in this article.

DURING THE past two years important changes have been made in the source of supply of low-voltage current for operating the sprinkler and fire-alarm, telephone, clock and other systems in the Lyon & Healy store and factory. These changes have resulted in such a marked decrease in operating and maintenance expense and trouble, with an equally marked increase in reliability and freedom from interruptions of service, that an account of what was done may be of interest to the readers of INDUSTRIAL ENGINEER who have conditions and problems similar to ours.

The store is in a ten-story building and requires an extensive alarm and signal service, as will be seen. The fire alarm system comprises two pull boxes and one 10-in. alarm bell on each floor. The alarm boxes are of the usual closed-circuit type through which a small current flows constantly. Through these boxes the alarm is sent in to the city fire department. The building is also equipped with a sprinkler system for fire protection. There are approximately 180 sprinkler heads on each floor. Two wet risers supply the sprinklers in which water pressure is constantly maintained, and one so-called dry riser is connected to the sprinklers in the display windows. All of these risers are equipped with switches whereby the alarm bells throughout the building and in the engine room in the basement are rung whenever a sprinkler head is opened either accidentally or by a fire. An annunciator in the engine room indicates the riser from which the open sprinkler is fed.

CURRENT FOR OPERATING electric clocks, fire-alarm, signal bell and other low-voltage systems is usually obtained from wet- or dry-cell batteries, or small motor-generator sets. Among the disadvantages connected with the use of these sources of supply is the possibility of complete failure of service through the development of trouble which may not be detected until the batteries are exhausted, as well as the amount of attention required and the expense of recharging or replacing exhausted cells. In this article Mr. Clausen describes the use of a device for reducing 110-volt direct current to any desired voltage and shows how an investment of $1,500 in equipment has made possible a saving of about $3,500 a year in operating and maintenance costs.

Correct time is shown throughout the building by an electric clock system consisting of one master, one program and thirteen secondary clocks. The program clock automatically rings a 6-in. bell on each floor at the time for starting work in the morning, at the beginning and end of the noon hour and at quitting time at night. The secondary clocks are, of course, operated and controlled by the master clock in the engine room.

There are in operation five passenger elevators, arranged in one bank of three and one bank of two, in the front and rear of the building respectively, and four freight elevators. Of the nine elevators seven are equipped with annunciator signals. The other two elevators are used only intermittently for carrying heavy freight. Annunciators on the passenger elevators have polarized target signals so that although a signal from any floor is registered on all of the elevators in that bank, the target is automatically restored as soon as any one of the elevators passes that floor. That is, when the button is pushed on the eighth floor, say, at the front of the building, the corresponding target in the annunci-

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ators of all three elevators registers the signal. If, then, elevator No. 2 is the first to stop at that floor, the target in the annunciators of elevators Nos. 1 and 3, as well as 2, is automatically restored. These annunciators require that the current flow sometimes in one direction and sometimes in the other, in order to restore the polarized target.

For general signaling purposes, calling officials to the telephone, and so on, there are on each floor two bells, one in the front and the other in the rear of the building. Two pushbuttons on the telephone switchboard enable the operator to ring either set of bells as desired. In addition there are about 175 buzzers and annunciators for summoning stenographers, office boys and clerks in various parts of the building.

The second floor is devoted to the demonstration and sale of Victrolas and for this purpose thirty-six sound-proof booths have been installed. To avoid confusion in assigning booths to prospective customers, use is made of a signal board which has been found very satisfactory. This board consists of a metal box with a ground-glass front on which are painted the numbers from one to thirty-six. Behind each number is one white and one red 5-watt, 12-volt lamp. When the customer enters a booth and closes the door, a door switch makes contact and lights in the signal board the lamp corresponding to the number of the booth. The dispatcher thus knows at all times which booths are occupied. Within each booth there is a pushbutton and a buzzer. If the customer desires additional records or other service, the salesman pushes the button, which lights the red lamp in the signal board corresponding to the number of the booth, and also lights a 5-watt lamp above the door of the booth. The attendant at the board is thus notified that something is wanted and sends a clerk to render the service desired. The white light above the door not only helps the clerk to find the booth quickly, but enables the floor manager to see that service is rendered promptly. The light is switched off by the salesman in the booth as soon as the desired attention has been received.

A part of the fourth floor is devoted to the sale of player pianos, and for demonstration purposes there are fourteen booths similar to those on the second floor and with the same signaling equipment.

Finally, we have an 8-station intercommunicating telephone system between the various departments. This system is of the common battery type and requires 17 volts for operation.

In addition to the store this company operates a large factory for the

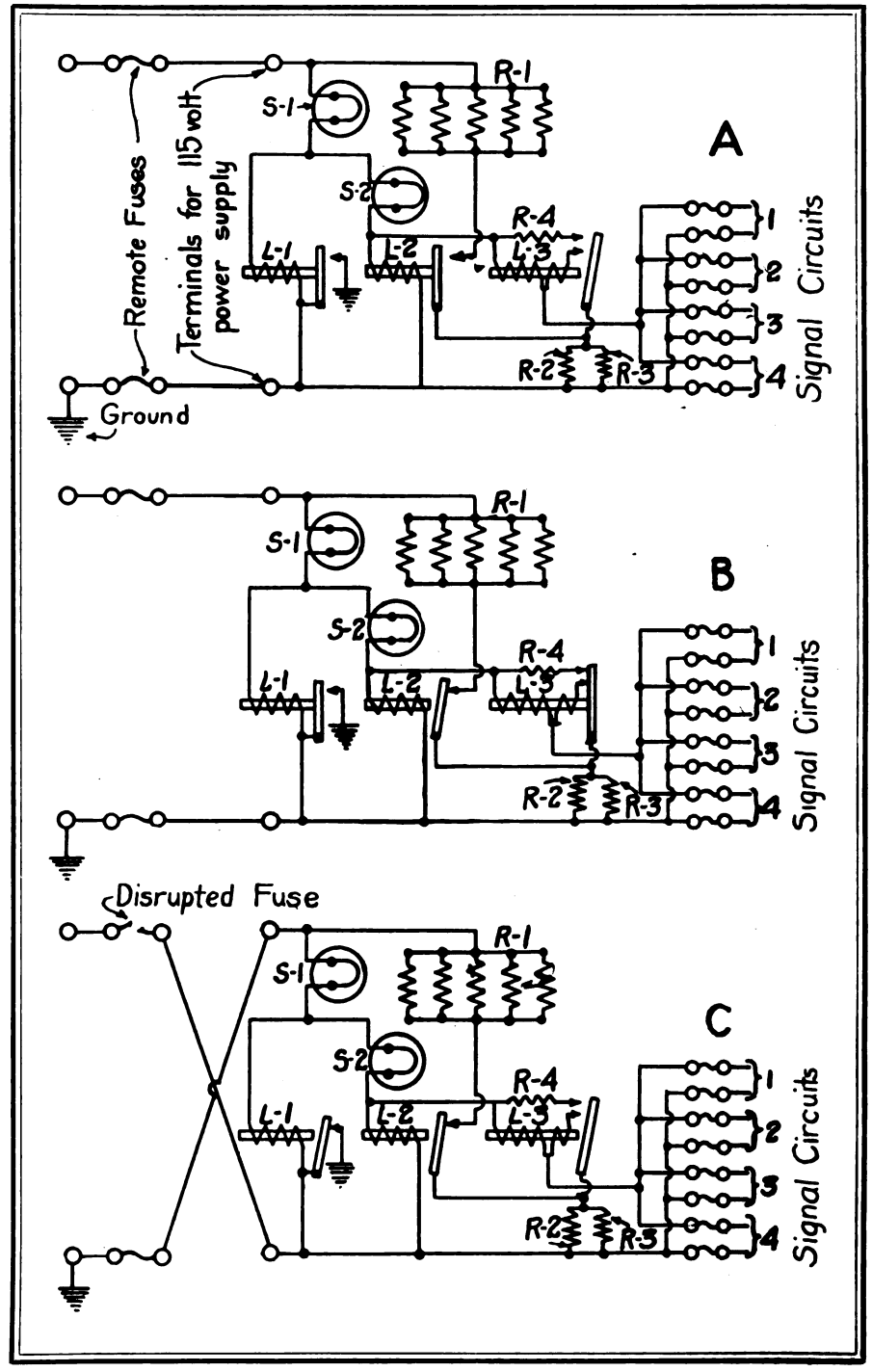


Fig. 1—This shows the operation of the controller under three different service conditions.

With the low-voltage side on open circuit, *A*, the connection is through lamps S^1 and S^2 and relay L^2 with a potential tap between S^2 and L^2, through L^3 to the positive side of the low-voltage circuit. The voltage on this circuit is determined by the relative resistance value of the two parts on either side of the potential tap. When the low-voltage circuit is closed, relay L^3, which has a double winding, is energized with a current of about 0.020 amp., causing the double contact to close, which reduces the voltage on relay L^2 and thus releases it. A connection is thus established through R^1, relay contact L^2 and resistances R^2 and R^3 in parallel. With the potential tap between the L^2 contact and the resistances R^2 and R^3 the operating potential of the low-voltage circuit is determined by the ratio of R^1 to the joint resistance of R^2, R^3 and the load. The resistance of R^2 is kept uniform while that of R^3 is varied to obtain the voltage desired. Relay L^1 for reverse-polarity protection is normally open so long as 110-volt power is on. If power service is interrupted and then resumed with reverse polarity or if polarity is reversed in connecting the controller, the contact of L^1 is closed and a ground connection made to the normally grounded supply main. This results in a short circuit and the blowing of the fuse in the power supply lead, as shown in *C*.

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manufacture of pianos, harps and a number of other musical instruments. This factory is in a 3-story building which is equipped with a sprinkler system fed by three wet risers and one dry riser for that portion of the system which protects the dry kilns and shipping platform.

The current for operating these various low-voltage electrical systems was formerly obtained from three small motor-generator sets supplemented by dry cells and storage batteries. On open-circuit work approximately 150 dry cells were used while the closed-circuit system, as well as the house bells, buzzers, annunciators, booth signals, and so on, were supplied by two 6-cell, 120 amp.-hr. storage batteries. One of the motor-generator sets, of 65-amp. capacity, was employed for charging these batteries, which were used alternately; that is, while one battery was in use the other was being charged. This generator was in service from eleven to twelve hours daily. The elevator signals were operated from two small motor-generator sets which reduced 220-volt direct current to 17 volts. Although this was found to be a fairly satisfactory method of obtaining low-voltage current, oiling the sets and keeping them in proper condition took some time, and in addition they frequently ran very hot, generally from grounds which often developed in the system and drew a comparatively heavy current. Once every year or two a set would burn out and we would be put to considerable trouble, as well as the expense of having the set rewound.

With the batteries, too, considerable trouble was experienced. In the first place, the expense of replacing the dry cells and recharging and maintaining the storage batteries was considerable. Besides this, grounds often developed on the various systems and by the time they were discovered the batteries were often completely exhausted and, in the case of the dry cells, had to be replaced. Under these conditions we could seldom or never be sure that the sprinkler alarm system was in working order, for serious trouble could, and has, developed within a short time after the system was tested and found to be in good condition. If the alarm fails to sound on the accidental opening of a sprinkler head, many thousands of dollars damage might be done to the stock of pianos and other fine instruments before the break was discovered and the water shut off. Furthermore, it was necessary nearly every morning to set each of the secondary clocks by hand, as trouble or lack of power during the night had put the clock system out of commission. Although the batteries could not, of course, be blamed for trouble in the wiring, the expense involved and the attention necessary together with the uncertainty of the service, due to the fact that trouble could develop without our knowledge, made their use far from satisfactory.

After an investigation, and with the Underwriters' approval, it was finally decided to install what is known as the Universal Electric Controller. This is a device designed for the purpose of reducing direct current at 110 volts to low-voltage direct current for the operation of any apparatus or system such as fire alarms, telephones, bells and the like, which are ordinarily operated by batteries or other sources of low-voltage current. For this purpose the instrument, which is a potentiometer, resistance appliance, is connected to a direct-current light or power circuit of 110 volts or more.

As will be seen from the accompanying illustrations, the equipment is arranged for convenience in three units, consisting of the controller or instrument proper, the resistance and a fused distributing cutout box into which the various low-voltage signal or other circuits are led. The controller is contained in a cylindrical case, the rear half of which is of cast iron. The front half is formed from sheet steel, with a flanged edge engaging the front of the cast-iron section and is fitted with a glass window. This case is 10-in. in diameter and approximately 6 in. in depth, the glass front having an opening of 7 in. The relays, resistors and terminal parts are mounted on ½-in. transite asbestos bases separated from the metal back of the case to provide wiring space. The resistors are all of wire wound in grooves on lava tubes. The ferrule terminals are of such size as to fit standard 60-amp. cartridge fuse cutout parts which are mounted on the base.

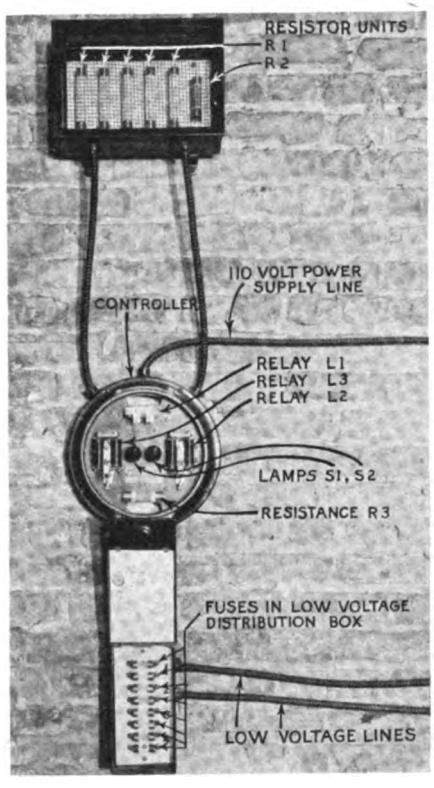


Fig. 2—Here is the way the controller, resistance unit and low-voltage distribution box are usually installed. This illustration also shows the relative position of the parts referred to in Fig. 1.

The resistance and distribution units are inclosed in sheet steel boxes of standard cutout type, with the resistance unit provided with a wire screen cover to afford free ventilation. The resistance unit is 12-in. x 8-in. x 4-in. in size with strap supports that provide air spacing of 1½ in. at the back. The distribution unit is supplied with special glass tube fuses and terminals for four circuits mounted in a steel box 9-in. x 5-in. x 3½-in., with a hinged cover and latch. By this arrangement it is not necessary to open the case containing any contacts directly connected to the lighting or high-voltage circuits in making the connections for the bell or other circuits. In the installation of this device which operates, of course, on a 2-wire circuit, one side of which is grounded, it is necessary to observe definite polarity connections. The controller will not operate when the polarity is reversed. Referring to Fig. 1, *A*, the circuits are seen to be arranged in a double potentiometer connection with an added connection to relay L^1 for reverse polarity protection. This connection is a constantly closed circuit and the relay does not function except on reversal of polarity.

The first or higher resistance potentiometer connection is through S^1, S^2, L^2, with potential taps between S^2 and L^2. This is also a constantly closed circuit. The voltage thus impressed on the signal system when open is determined by the relative resistance values of the two parts on either side of the potential

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taps. That is, if the resistance toward the ungrounded supply main is four times that of the resistance toward the grounded main, then the voltage toward the ungrounded main is four times that of the voltage toward the grounded main. This latter voltage is that which is impressed on the signal system terminals. Thus there is about one-fifth part of the line voltage on the signal system with the normal open signal circuit condition.

The high resistance potentiometer connection affords supervisory voltage with a small power loss.

With a closed-circuit signal system the current energizes L^3 and with a value of about 0.020 amp., causes the closing of its double contact. This results in a lower voltage on L^2 with a lessened current which causes L^2 to release, as shown by Fig. 1, *B*.

The second or lower resistance potentiometer connection through R^1, relay contact L^2 and resistances R^2 and R^3 in parallel is then established with its potential taps between the L^2 contact and the two resistances in parallel. The potential taps of the two potentiometer connections are thus joined through the contact of L^3. The purpose of the additional winding on L^3 is to obtain a greater pressure on its contact by means of the additional magnetic pull.

The operating voltage of the signal system is determined chiefly by the ratio of R^1 to the joint resistance of R^2, R^3 and the load. With 115 volts impressed on the device and R^3 removed, the voltage impressed on the signal system decreases from 24 volts to zero, with increase of signal load. The value of R^2 is made uniform for all instruments of the type described here. Resistance R^3 is employed to obtain lower operating voltages and is, therefore, selected in each case according to the voltage desired.

The operating characteristic has the two limiting conditions of current merely sufficient to operate the relay at maximum voltage and a maximum or short-circuit current at almost zero voltage. At both limits the power output is small and definitely limited. In other words, even on a short circuit the current flow cannot exceed a predetermined value. The maximum power output occurs with approximately one-half of the maximum voltage and one-half of the maximum current.

The reverse-polarity protective relay, L^1, releases with any interruption of the power supply. Its contact is thus closed and a local ground connection is made directly to the normally grounded supply main. Should power be resumed with reversed ground polarity, a short-circuit occurs which renders the device inoperative and causes the blowing of a circuit fuse in the supply power lead. This condition is shown in Fig. 1, *C*.

The two small lamps, S^1 and S^2, serve both as resistors and as visual signals. With a signal circuit open they are dimly lighted. With a signal circuit closed or in operation they are slightly brighter. With failure of power supply they are extinguished. Further, under service conditions the opening of the circuit in the grounded wire, as might be produced by the blowing of a fuse, causes the armature of relay L^1 to drop, thereby establishing a local ground connection. This, in effect, is the same as re-establishing the supply circuit and causes L^1 to lift its armature again, at the same time breaking the ground contact. This sequence of operation continues as a vibrating chatter until the neutral fuse is replaced. The controller thus indicates automatically the presence of abnormal conditions such as failure of power supply, blowing of the fuse in the ground connection, or shorts or grounds in the signal circuits.

Our experience in the use of one of these controllers as a source of low-voltage current for the sprinkler alarm system in the store was so satisfactory that altogether eleven have been installed to operate, in both store and factory, the various signal and other systems previously described. The illustration at the beginning of this article shows a bank of four 17-volt, 5-amp. controllers with the resistors and cut-out boxes. Controller No. 1 at the extreme left of the illustration supplies the current for operating the house bells, annunciators and general signaling equipment throughout the building.

Controller No. 2 operates the open-circuit sprinkler alarm system, whereby, in the event that a sprinkler head opens an alarm is sounded throughout the building and on a bell outside, to call the attention of the Watchman Service police, and an annunciator indicates the riser involved.

Current for the time-stamp and electric-clock systems is supplied by Controller No. 3. Controller No. 4 supplies energy for operating the booth signals. Inasmuch as there are fifty booths in all, making a total of one hundred and thirty-six 5-watt

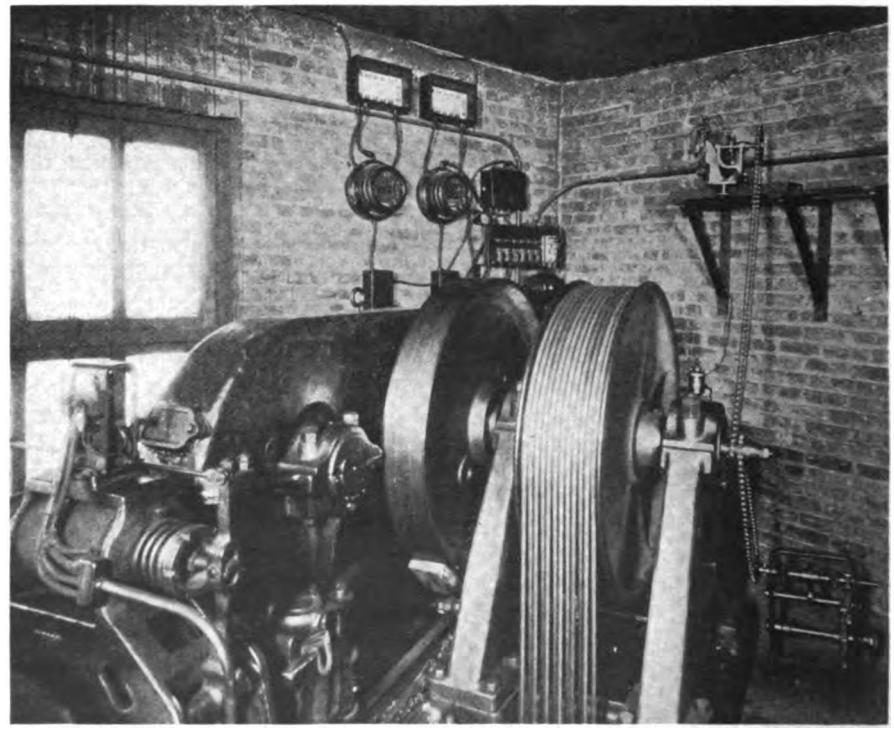


Fig. 3. These controllers replaced two small motor-generator sets for operating the signals of the passenger and freight elevators.

It was necessary to use two controllers, connected together to form a three-wire system, in order to operate the signals, which require a reversing current. One of the generators previously used may be seen below and to the right of the controllers.

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red and white lamps, besides the buzzer signals, the possible load when all of the booths are occupied is beyond the capacity of the 5-amp. controller. Inasmuch as we had a 65-amp. motor-generator set which had been used for charging storage batteries and was in good condition, it was decided to use this for carrying booth loads which are too heavy for the controller. The circuits are now so arranged that by the use of two relays the motor-generator set is automatically started and picks up the load when this reaches 5 amp. The controller is at the same time disconnected on the low-voltage side.

Mention was previously made of the fact that the elevator signals require that current flow sometimes in one direction and sometimes in the other. This condition was met by using two controllers, shown in one of the illustrations, connected together. It is, of course, very essential that there be no interruption to the elevator signal service. For this reason the circuits were arranged so that the signals can be operated also from the 25-amp. motor-generator sets formerly used for this purpose, in case of trouble with the controller. There has, however, been no reason to switch over to these sets since the controllers were installed, nearly two years ago.

As one low-voltage system after the other was taken off the batteries or motor-generators and put on the controllers, we found that our operating and maintenance costs for the kinds of service indicated above were being reduced to a small part of what they were previously. The controllers require no attention whatever, so that maintenance is now mostly a matter of clearing an occasional ground or short circuit on the alarm and signal systems. By reason of this fact we were able to dispense with one troubleman and thus affect a saving of approximately $1,500 a year. On account of the greater reliability of the sprinkler alarm system, the insurance companies allowed a reduction which amounts to many hundreds of dollars a year on the premiums for insurance against damage by water from accidental opening of sprinkler heads, both in the store and in the factory. There is a further saving of nearly $800 a year in the power which was formerly used in charging the storage batteries. Altogether, it is estimated that a saving of $3,500 a year is being realized on an investment of about $1,500 in controllers.

Results of Careful Inspections

(*Continued from page 235*)

mounted on a cast-iron pedestal, with contactor switches placed at one side and held on a panel with sheet-iron guard and ample ventilation as indicated. A ½-hp., 220-volt motor drives the press, and starting and stopping is governed by a lever within easy reach of the operator. The lever connects with a switch in the conduit line shown and is arranged to release a mechanical brake when the power is thrown on. Such machines were formerly group-driven from overhead and the elimination of belting and shafting is a decided gain to the department.

A typical guard for a motor starting contactor group and switch as designed for Dennison service is shown in this illustration and another in *D* of Fig. 4. This guard is of metal, and is open at the sides and bottom to insure ventilation. A hand-hole for the speed control switch is shown, and at the top of the panel is mounted the push-button control. The motor in *D*, of Fig. 4, is mounted on a bracket designed for this machine by the company's engineers. Rigid conduit protects the wiring and insures compactness of layout.

Noteworthy saving in space is made in the case of a gear drive of a printing machine (not shown), from a 3-hp., 220-volt motor, speed 825 r.p.m. The motor is mounted on a cast-iron bracket about 5 ft. above the floor, and is geared through a rawhide pinion to a flywheel gear mounted on the main driving shaft of the machine. This arrangement represents the last word in compactness in gear driving, and it combines space-saving qualities with quietness of operation. The motor is lined up with fiber shims and fiber washers are used under the bolts to prevent electrical leakage. Push-button control is provided, with start and stop buttons at each end and in the middle of the machine on either side. These machines were formerly driven from overhead line shafts. Under the new arrangement there is no chance for oil and dirt to drip upon the product in process from the overhead belting, and the mounting of the motor at the end of the machine and at the height above indicated greatly facilitates inspection. The wiring is protected in rigid conduit and the contactors and resistance are well housed at one side.

Excellent protection of motor and driving belt, with unusual compactness of wiring are achieved in the case of a Knowlton & Beach staying machine (not shown) individually driven by a 1/3-hp. motor. A bracket at one side carries the motor and extended strap-iron pieces support the conduit riser from the floor, the fuse block and snap switch for motor starting and stopping. The belt from the motor shaft pulley to the machine shaft is completely inclosed and a cylindrical extension piece hinged at the top guards an extension of the main shaft. The motor is fed by a short run of wire in circular loom from the condulet outlet beneath the oil guard.

A group of protective and control services mounted on one column in one of the productive departments is shown in *B* of Fig. 2. Here are centralized a local interior fire-alarm box, a watchman's signal box, a motor switch and speed control for a near-by power unit, a thermometer, a fire-alarm and signal gong, and a chemical extinguisher.

In conclusion, a few words may be added about the problem of illumination. The Dennison company is making a study of the desirable intensity of illumination to be used in various parts of the plant, and in general the tendency is toward increasing the former values. Where from 2.5 to 5 ft.-candles formerly were utilized, the tendency is toward using 5 to 10 ft.-candles. In the offices 200-watt lamps are being replaced by 300-watt units, and from 8 to 9 ft.-candles are being scheduled. In the company's new factory just being completed at Marlboro, Mass., an intensity of 8 to 10 ft.-candles will be utilized on the work tables in jewelry-box manufacture, and about 5 ft.-candles around box machines, slitters, etc. In the wiring there is a policy to subdivide the service to permit throwing on interior lamps before locations nearer the windows require artificial illumination. In typesetting, the intensity is being raised from 5 to about 8 or 9 ft.-candles. No more drop lights are being installed in the plant, and the use of metal reflectors has not been found as satisfactory as the utilization of prismatic shades, with their pleasing distribution in connection with light-colored walls and ceilings.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, May, 1923

There Are No Snakes in Ireland!

MANY MEN responsible for maintenance and operation in industrial plants are looking for the perfect belt joint suitable for all purposes. However, like the snakes of Ireland, there are none. Of the dozens of belt fasteners which are available, and many of them good, perhaps none can be classed as the best for every purpose. In the case of belt joints, as with almost every other trouble-maker, one of the best methods is to eliminate the joint, or in other words, make the belt endless. This, however, is only practicable with leather belts, and even then, not under all operating conditions. On a belt put in temporarily or where the pulley diameter is changed frequently, as on some grinders to take care of decreased diameter of wheel and in similar locations, it is often doubtful whether or not the cemented joint is the most practicable. In many cases, as with side belts on wood planers or other places where uneven spots in the belt are not desirable, endless belts are usually more satisfactory and may be made so by the belt manufacturer so that the plant man has only to install them. In many cases these belts have idlers or tighteners to maintain tension and take care of any slight stretch. If the belt length is determined properly, usually but little stretch occurs with a first-quality leather belt. An endless belt is, at least theoretically, uniform throughout, that is of equal strength, equal width, equal thickness and uniform flexibility. Some of these qualities, however, must be sacrificed in using any other type of fastener. In addition, fabric-base belts cannot be satisfactorily made endless on the job, without sacrificing flexibility.

To overcome one of the greatest objections to endless belts—the time required to make the joint on the job—many metallic fastenings are offered to belt users. Due to the speed and ease with which they may be installed and their reliability, if the proper sizes and types are put on with enough care and workmanship to not be ashamed of, metallic lacings are increasing rapidly in popularity. Some examples of workmanship any maintenance man should be ashamed of are shown on page 238 along with some he can be proud of.

The Dark Horse in Production Control

IN EVERY industrial works a schedule of production is as essential as the orders on which it is based. But between receipt of the order and the shipment of the product there is a wide range of activity which includes the preparation and handling of raw materials at machines and between processes and departments so that when a production schedule is carefully laid out the essential parts will reach the point of assembly at the time needed and the product will arrive at the shipping platform with the fewest possible hitches and delays that cannot be foreseen at the start.

The greatest source of these hitches and delays can be usually traced to errors in judgment, disappointment in promises in the delivery of auxiliary equipment and parts purchased outside and unexpected delays in production through lost time, accidents and breakdowns in production equipment. In a plant that is rushed to capacity the losses from accidents and breakdowns may be so large and so serious that a production schedule which does not provide an adequate insurance against them through continuous inspection and attention to minor repairs before they become serious, will show a waste that will represent a large percentage of the possible profit on the work being handled. Here then is a weak spot in production control that is weakest when a plant is loaded with orders—a time when adequate thinking on continuity of machine operations and power service will show its greatest return.

In one large works the division of responsibility for continuous production is divided into three groups: (1) the engineering group "which tells how to do the job," (2) the production group "which tells what to do it with," (3) the manufacturing group "which does it." This plant has few breakdowns and few unexpected accidents for the group "which does it" has a definite organization "which keeps things going" in the process of doing the job. Here is the secret of production control in this plant and it's the same for any other, large or small. It's the "keep things going" group of men who know where reliability in systems and machines lies and from what kinds and types it can be secured. On their judgment and experience the "what to do it with" group draws when executing the division of responsibility in production that falls to them.

What Can Be Done in Fifteen Minutes a Day?

IT IS a common habit to belittle a loss or waste that appears trivial. A few extra inches of wire cut off and thrown away, five or ten minutes wasted in "visiting," or any of many other similar items, are ignored as of no consequence. Each waste by itself is a small matter but in the aggregate they amount to considerable. The commercial value of such trifles is well shown by the reported statement of a wealthy manufacturer of mustard dressings who said: "I did not make a fortune from the mustard people eat, but from that which they leave on their plate."

Wasted materials that show up as scrap or junk are easily seen. But many other wastes, such as lost time are less easily discovered and run into astonishing totals. For example, the value of only fifteen min-

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utes of wasted time a day amounts to about $30 for each $1,000 in wages, or about the equivalent of a week and a half in a year. Those who ask "What can be done in fifteen minutes a day?" can find out by asking: "What can be done in a week and a half?"

Guesswork vs. Investigation

WITH the wide attention which is being paid to the problems involved in lighting industrial works, it is inevitable that mistakes will be made when the solution of some of these problems is attempted by men who have had little or no experience in this work. As a case in point the electrical department of a large works has lately revamped the entire interior lighting system by eliminating all drop lights and installing a localized-general system of illumination. Unfortunately the results have not been altogether satisfactory. The workmen in some of the departments are protesting vigorously that the new system is not giving them sufficient light and is, therefore, making their work harder. The head of the electrical department has met these complaints with the assertion: "Those old men think they are not getting any light unless they see a drop cord in front of their noses." There the matter stands. Each side thinks that the other is trying to "slip something over." Both contenders are holding their position firmly and the result is a situation that is not conducive either to harmony or maximum production. No one knows the real merits of the case—and that is just the reason there is a controversy. It is entirely possible that a few hours spent in taking foot-candle readings and interpreting these from the standpoint of what the illumination requirements for certain classes of work are, would show that more light should be allowed in certain areas. Up to the present no such tests have been made. Guesswork and stubbornness have taken the place of investigation. Arbitrary methods may be justifiable at times; however, as someone has said: "If you are sure you are right, go ahead—but first be *sure* you are right."

Work With a Chisel Instead of a Horn

WHEN the best you can say of a job is that it is good enough, and when a repair job looks like a countryman's harness all tied up with a string, you get a definite impression of the kind of thinking that men responsible for such work do, even though they seem to have the usual excuse of being too busy with other big jobs to attend to the details of the smaller ones. This is one sign of waste. There is another equally bad. It is found in those cases where a plant man spends much time and money in putting in super-refinements on a job, where a less expensive and less complicated layout would function equally as well, for the sole reason of being able to show his advanced ideas and the niceties of installation details and talks about these as evidences of his ability and knowledge of first-class work. The man whose engineering judgment is so warped by his good opinion of himself is not much better off than the one who is careless and sloppy, for both are wasters.

Between these two extremes is the man whose engineering judgment is based upon common sense, a thorough analysis of operating requirements and expected results checked against the costs plus maintenance service. He is the man who works with a chisel instead of a horn and leaves behind him evidences of business as well as technical thinking in the work he does that requires no long reports or elaborate data to justify the expenditures he makes.

Moreover, such a man when he carries the title of foreman, millwright or some such title that connects him with the details of some particular job, is not considered by his employer as in the labor group but in that division that carries responsibilities for production. In that sense he is an operating representative of the executive with whom he works—not simply one of a group working for this executive and paid for the time put in.

The good jobs of today and tomorrow are going to be held by the men who appreciate this viewpoint and show through their work that they appreciate their opportunity by exercising initiative and responsibility to increase production and control its cost. If such a man works with a chisel instead of a horn his work will be his testimonial for larger responsibility and the salary that goes with it.

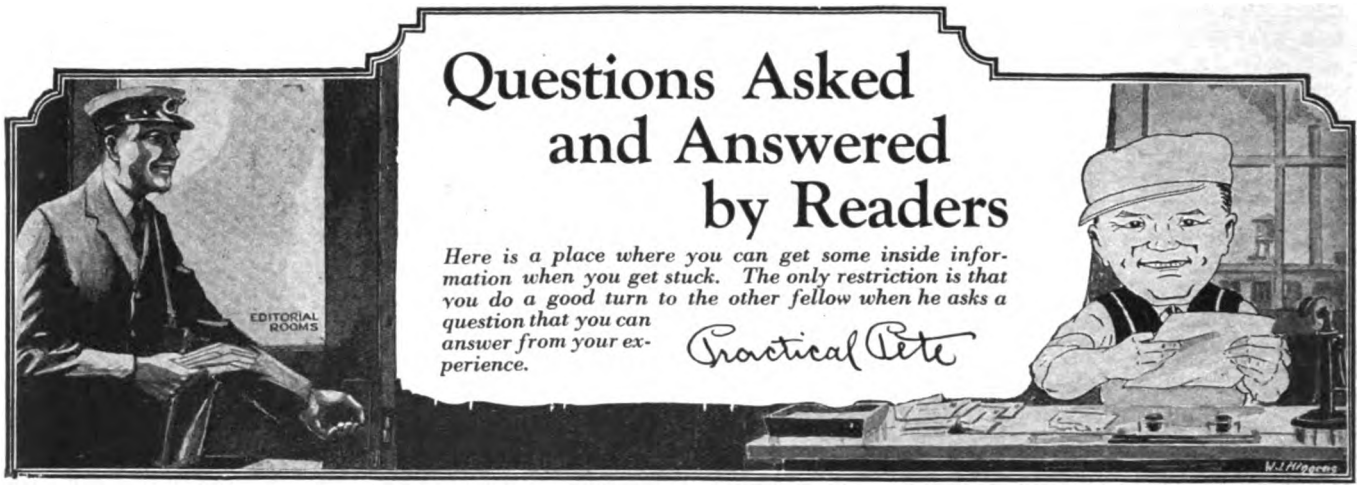
Attention That Pays Dividends

WHEN A FIRE starts in a plant the attention directed toward getting fire fighting equipment into action is in keeping with the possible disaster that may result. This kind of attention pays dividends when a fire actually starts. But relatively few fires are disastrous in the full meaning of this word and the reason is directly attributable to fire fighting precautions.

In every works, large or small, normal wear and tear plus the results of indifference and carelessness set up conditions that result eventually in losses of the same order as the destruction caused by a fire. Results of wear and tear do not always show up on the surface and it takes a trained eye and ear to detect them in the early stages of their seriousness. When things are running nicely a man looking for trouble is too often viewed as a trouble maker but in the long run such a man skilled in his work, produces profits just as truly as the man at a machine who performs an operation in a process of production, for he makes it possible to get continuous production from that machine at a definite predetermined and uninterrupted rate.

In a large works, attention in the form of skilled inspection along the line of power service where the responsibility of machine operators neither begins nor ends at any particular point, makes it possible to know what spare parts are needed in case of a breakdown and just where to anticipate troubles without waiting for them to show up. Serious breakdowns rarely occur on battleships and locomotives on fast trains, because of precautions through inspection and the knowledge that small repairs of defects that look like trouble makers cost about 1 per cent of repairs that actual failures demand. Attention through inspection, therefore, turns the remaining 99 per cent of the possible repair expense into cash dividends.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Contact Points on Electric Bells—What is the best metal other than platinum, to use for contact points on electric bells and gongs? If several kinds can be used, will you please indicate the order of their suitability, as first, second, third, etc.?
New Orleans, La. P. B. A.

* * * *

Armature Insulation—What is considered the best types of slot insulation that varies from 5 to 10 mils in thickness, considering pliability, mechanical and electrical insulation and deterioration in stock?
Albert, W. Va. F. H.

* * * *

Cleaning Transformer Cores—Will some reader of INDUSTRIAL ENGINEER tell me what method he has found best for cleaning transformer cores that are to be rewound.
Americus, Ga. B. B.

* * * *

Current Drawn by Testing Transformers.—In the January, 1922, INDUSTRIAL ENGINEER page 45, there was shown a transformer for testing armatures. I wish someone would tell me just how many amperes this will draw on a 3-phase, 60-cycle, 115-volt circuit.
Murrieta, Calif. F. D. O.

* * * *

Winding a 1 to 1-Ratio Transformer—I want to wind a 1 to 1 transformer for 110 volts primary and 110 volts secondary and apply both primary and secondary wires at the same time. This would put the secondary winding in contact with the primary winding through the entire length with no other insulation between them, except that which is on the wire. What insulation would it require to withstand the stress for this kind of an arrangement? Would it require enamel and double cotton, enamel and single cotton or would double cotton be sufficient?

If I understand it correctly, when the primary pressure is a maximum the secondary pressure is zero, and when the secondary pressure is maximum, the primary is zero. Is this correct? If so, the emf. or current would not pass from one winding to the other, except when the secondary was grounded.
Logansport, Ind. L. E. G.

Object of Short-Circuiting Ring on Field Coils—Recently one of my men was retaping the field coils on a 10-hp. motor. These coils had a copper piece on the insulation the width of the coil and the coil wound on same. This assistant asked me the object of this construction. Is the following answer correct? When opening the shunt field there is a high inductive kick which this short-circuiting ring takes up and thus safeguards the insulation against puncture.
Chicago, Ill. V. L.

* * * *

Mounting Motors—Should electric motors run in a horizontal or vertical position? Is there any difference in their performance in such positions, from an electrical standpoint? Practical motor men have told me that motors in a vertical position do not give the same service and satisfaction as the ones operated in a horizontal position. Some argue that when a motor is running in a vertical position that the rotor centers itself in the magnetic field so that there is no more wear on the lower bearings than on the upper ones. What is the opinion of readers of INDUSTRIAL ENGINEER on this question?
Lancaster, Pa. K. M. C.

* * * *

Rewinding Desk Fans—We have to rewind 16-in. desk fans of Westinghouse and Colonial make, and I would appreciate if some of the readers will answer the following questions: How many turns and what size wire should I use for the armature coils? What is the coil pitch? There are twelve slots and twelve bars in the Westinghouse fans and fourteen in the Colonial. When the armature is mounted in the winding machine should the upper end be turned toward the operator or away from him when winding? Should the leads be brought out on the side nearest to the operator, or on the opposite side? What is the pitch of the commutator leads and does it make any difference whether I swing them to the right or to the left? This is a lap winding, and there is more wire in the last coil than in the first coil, assuming the same number of turns on all coils. Will this cause sparking at the brushes?
St. Louis, Mo. W. G. W.

Answers Received To Questions Asked

Trouble With Sparking at Brushes—Will you please answer the following and explain what the trouble is? We have a 500-kw. rotary converter which has for some time been giving trouble from sparking. The commutator has been turned down and slotted and still it is sparking. The spark is a light blue, leaving the brush on the leading side. It does not burn the commutator and acts like a static spark. It is not quite so bad when running with the compound switch in.

We have been over the field connections and everything else we could think of that would cause it to act this way. What do you think the trouble comes from?
Natick, Mass. J. A. P.

This will answer J. A. P. of Natick, Mass., on trouble with sparking at brushes. Examine the under armature leads where they fasten to the commutator bars. You will probably find some of them worked loose and making a poor contact. By resoldering them the sparking will be stopped. This proved effective on a 500-kw., 600-volt motor-generator set in our plant. EARLE N. DILLAN.
Chief Electrician,
Booth-Kelly Co.,
Springfield, Ore.

* * * *

How to Figure Ampere Rating of a Cable—How can I find the rating of a cable when I know the number of wires in the cable and the size of these wires? For instance, what is the rating of a cable that is made up of seven No. 14 wires?
Sartell, Minn. L. S.

Regarding the query of L. S. as to the ampere rating of a cable, to find the ampere rating of a cable multiply the cross-sectional area of an individual strand by the number of strands composing the cable. Thus for the cable of 7 No. 14 B & S wires we find from a wire table that the cross-section area of No. 14 B & S is 4107 circ. mils. $4107 \times 7 =$ 28,749 circ. mils total area. From

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the table we find this to be a value nearest to No. 6 B & S, which has an area of 26,250 circ. mils. For rubber insulation this is rated at 50 amps., and 70 amps. for other insulation. J. B. RAKOSKE.
Detroit, Mich.

* * * *

In answer to the question by L. S. on cable rating, I find the simplest way to determine the size of a cable is to look up the circular mil area of the wires of which the cable is composed and multiply this area by the number of wires in the cable. Then look up the wire size which is nearest to the result in circular mil area.

As an example take the cable made of seven No. 14 wires. Reference to wire tables shows the circular mil area of No. 14 wire to be 4,107. Multiplying this by seven gives a total circular mil area for the cable of 28,749. From the tables the wire with the circular mil area nearest in size to this figure is found to be No. 6. This is therefore the equivalent size of the cable and it will have approximately the same ampere rating as a No. 6 solid wire.

This method can also be applied to making up temporary emergency cable as follows: A No. 4 wire is rendered useless in a cable run and the only wire on hand is found to be No. 10. Reference to the wire table shows the circular mil area of No. 10 to be 10,380 and of No. 4 to be 41,740. Four No. 10 wires will therefore be required to replace the No. 4.
Comerio Falls, FREDERICK KRUG.
Bayamon, Porto, Rico.

* * * *

In the March issue of the INDUSTRIAL ENGINEER, L. S. asks how to determine the carrying capacity of cables and gives, as an example, one of seven No. 14 wires. If he will refer to the Regulations of the National Board of Fire Underwriters, better known as the National Electrical Code, he will find his answer there under the heading "Standardized Stranding." The rating given there is 50 amp. for rubber insulation; 60 for varnished cambric; and 70 for other insulations.

In cases where the stranding is not given in the table mentioned above, it is possible to figure out the proper rating by looking up the circular mils in each of the strands and then multiplying them by the number of the strands, the sum being the number of circular mils in the entire cable. For instance, in the cable mentioned each strand has an area of 4,107 circ. mil, so that seven would have 28,749 circ. mil. A cable of this size would be between No. 5 and No. 6 wire and, in order to "play safe," the rating of the smaller wire should be taken. If the carrying capacity of a No. 6 wire is looked up in the National Electrical Code, it will be found to be the same as that given in the table for "Standard Stranding." G. H. MCKELWAY.
Westfield, N. J.

* * * *

Elimination of Arc Lamp Noises—Will some reader please tell me how I can overcome the noise in a. c. arc lamps.
Bridgeport, Conn. G. R. C.

This will answer the question by G. R. C., Bridgeport, Conn., in the March issue on elimination of arc-lamp noises. The humming sound of an a. c. arc lamp is due to the expansion and contraction of the arc, caused by the rise and fall of the current. These variations produce vibrations in the air and a hum that varies in pitch with the frequency.
JOS. B. HUMPLEY.
Chief Electrician,
Blatz Brewing Co.,
Milwaukee, Wis.

* * * *

Trouble From Grounded Circuit.—Recently we were asked to look over a motor circuit for a school which had grounded all of the radiators in the school house. It was a 3-wire, 110-220-volt line entering the building in conduit with a grounded neutral on a pipe. We cut this ground and rung out the circuit and found no other grounds. As the motor does not run mornings we went away only to be called again in the afternoon. This motor is bolted on two pieces of wood in cement and has been running for four years and never given any trouble until this Spring. All the rest of the wiring was O. K. and we let the job go. There has never been anything done as the janitor gave instructions to keep hands off the radiators. What could be the possible cause of this trouble?
Saranac Lake, N. Y. L. J. R.

Regarding the trouble reported by L. J. R. of Saranac Lake, N. Y., in the February issue, since the test showed no grounds on the motor or house wiring when the grounded leg was open, I would suggest that test be made for electrostatic trouble, probably caused by the motor belt.

I presume the motor belt runs close to a radiator or some pipe of the heating system. The heating system is effectively insulated from the ground, and acts as a condenser for the static accumulation from the belt. When a pipe or radiator is touched, a discharge takes place through the person. The potential is so high that a dry wood floor is no insulator against it. The writer has made tests where static from an 18-in. belt jumped a gap of one foot past the full length of a 24-in. wood rule and severely shocked the person holding the rule.

The remedy is to place a metallic comb across the top of the belt and ground it. Also ground the heating system. WILLIAM MCNALLY.
Brooklyn, N. Y.

* * * *

Device for Testing Windings of Small Motors—Will someone be good enough to describe a small testing transformer or similar device such as described on page 45 of the January issue of INDUSTRIAL ENGINEER, that can be used for testing the windings of fractional horsepower motors for short-circuits, grounds, open circuits, and the like?
Nanty-Glo, Pa. S. J. S.

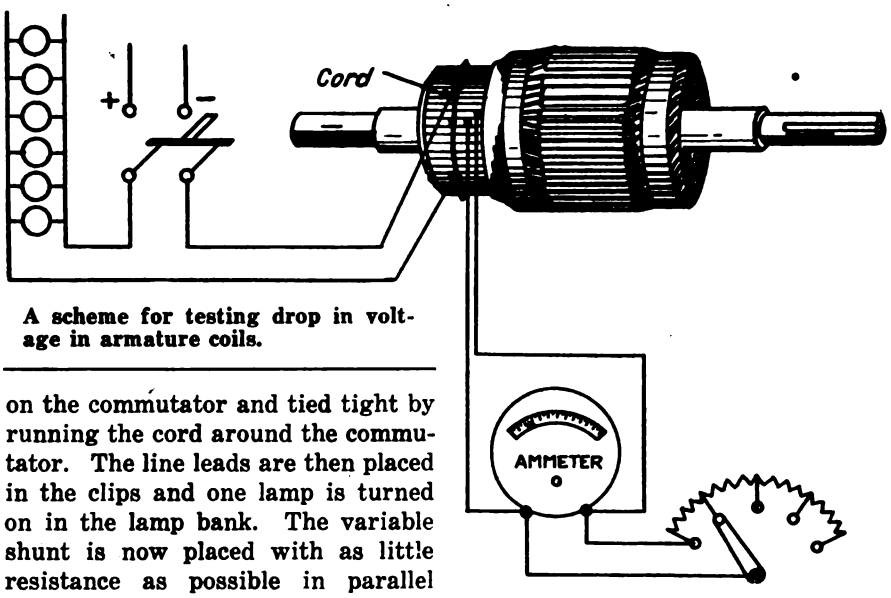
I have read with a great interest the articles published so far in "our" magazine concerning the testing of armatures, using the method of telephone receiver and battery, single lamp circuit and receiver, buzzer, etc., and feel that I can give you a better one yet, so I am here presenting a method which we use extensively with excellent results in the shop where I am employed.

The apparatus consists of a lamp bank of eight 120-watt carbon lamps, with test leads in series with the circuit, a pair of contacts to be attached on the commutator of the armature and a millivoltmeter with an adjustable shunt with leads coming from the meter binding posts. I am enclosing a drawing with all apparatus shown in position for use. The millivoltmeter we are using is an ammeter with the heavy shunt removed and a volt scale instead of an ampere scale so that the readings will be more noticeable, due to more divisions on the scale.

The contacts used on the commutator are made from 5/8-in. round bronze, 3/8 in. thick, with holes through them for a cord to pass. A small screw is put in the top of each contact to hold it in position on the cord. These contacts have to be placed at various distances apart, depending on the resistance of the armature being tested. The contacts are slightly concave on the bottom, to fit the commutator. Leads about 18 in. long are soldered on the contacts and at the other end of the lead a clip is fastened so that the live lines may be attached.

The method employed in testing is as follows: The contacts are placed

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A scheme for testing drop in voltage in armature coils.

on the commutator and tied tight by running the cord around the commutator. The line leads are then placed in the clips and one lamp is turned on in the lamp bank. The variable shunt is now placed with as little resistance as possible in parallel with the millivoltmeter. Then by touching the leads which come from the meter binding posts on two adjacent commutator bars, the needle will be deflected. These leads should have sharp-pointed nails soldered to them. If the needle reads backwards, reverse the leads as you place them on the commutator bars. After noting the deflection of the meter in the proper direction, the reading may be increased by inserting more of the variable shunt winding in the circuit. This meter shunt is wound with a lot of small wire, about No. 22. This causes less current to flow in the shunt and more in the meter. If this does not give a high enough reading, another lamp may be inserted in the lamp bank.

When testing armatures that are wound with fine or comparatively small wire, we find that one or two lamps with the use of the shunt will give a very desirable reading. Where the armature is wound with heavy wire, several lamps must be used and many times the shunt winding must be eliminated from use with meter. This allows all the current to go through the meter. By varying the position of the contacts on the commutator, a different reading is obtained also. The nearer they are, the higher the reading, and vice versa.

The results obtained by using this method are as follows: When all coils produce the same reading, the armature winding may be considered in good condition. Where a higher reading is obtained than the regular reading, this denotes a poorly soldered connection or partial open circuit. A very high reading denotes a complete open circuit. Where a lower reading is obtained than the regular reading, it denotes a short-circuit, which may be in the coil or in the commutator. This method will not show small carbonized spots in the mica, but will show a slightly lower reading if the carbonized spot is producing a short-circuit sufficient to produce trouble under ordinary conditions.

When the armature is one where the coils are connected in series or as we know it, a (1) and (2) connection, the trouble will be at the place where the different reading occurs. When the armature coils are connected on the half, the different readings will be found on opposite sides of the commutator, and in the case of a short-circuit the reading will be two low readings on one side and one lower on the other side. The lower reading is where the trouble is. The same effect and result is found in the case of a poor connection, except that the highest of the three readings shows the trouble.

This apparatus may be used to show where a grounded coil is. The method employed is that the leads from the meter are placed, one on the shaft and the other on the commutator. The needle will read forward and backward as the meter lead is moved over the commutator surface. When the needle reads zero the grounded coil is found, although it may be necessary to move the contacts around the commutator in several places as in some places the needle will read backwards on one bar and forward on the next. When the lowest possible reading is found, the leads are lifted and the ground is found to be either in the coil or commutator.

When the armature is connected on the half, it will be necessary to lift leads on the opposite side from where the lowest reading is found, in order to release both ends of the coil from the commutator, so that a direct test may be made on the coil with the live leads.

This apparatus may also be used to check the resistance of shunt fields by putting each field in the circuit separately to see if they all read alike. This circuit is made by putting the field coil and meter in series with the lamp bank across the line. I feel sure that anyone who installs this apparatus will be amply repaid by the results, as it is used in our shop altogether as the means of testing all the armatures we rewind and repair.

Darby, Pa. GEORGE W. HANLON.

* * * *

Location of Starting Equipment for Synchronous Motor—We are about to install a 350-hp. synchronous motor on a circulating pump. Would it be practicable to install the starting equipment about 100 ft. from the motor at the main switchboard, although the man starting the motor would not be able to see it? However, a man standing about 25 ft. from the motor could easily signal the operator. The main switchboard is on a gallery above the motor and if possible we would like to have the switchboard operator handle the starting and stopping of the pump.

Hudson, N. Y. F. R.

In reply to the question by F. R. of Hudson, N. Y., as to the practicability of installing the control equipment of a synchronous motor on a switchboard out of sight of the motor, it is well to refer to Rule 8 on motor switches, page 20 of the National Electrical Code.

The last sections of section C on page 21 state that "the switch and starting device must be located within sight of the motor, except in cases where special permission to locate them elsewhere is given in writing." Also "when auto-starters are used, a switch * * * must be within sight of the starter or starters controlled."

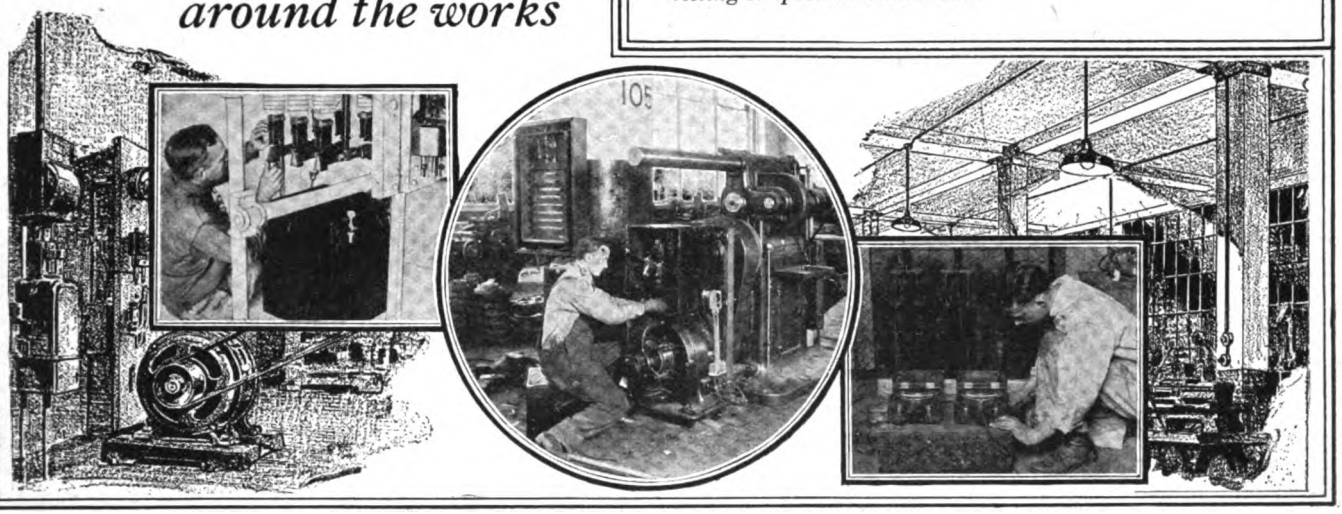
The rules are made for the use of wiremen, and the reason, of course, in this case is to insure proper inspection of the apparatus every time it is put into service. If the man who starts the motor can see it, he unconsciously will look at it and notice any disturbance or unnatural actions. It is not advisable to install the apparatus in any other way.

Boston, Mass. E. A. GIBBS.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

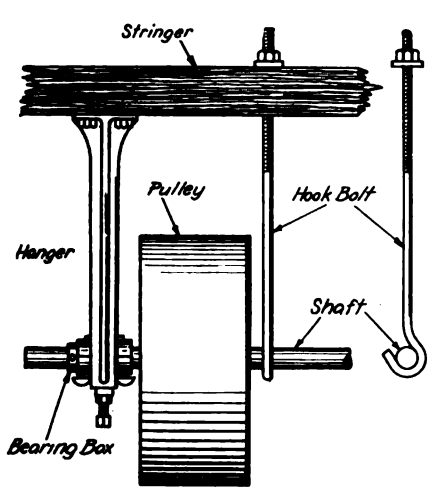


Simple Method of Removing Solid Rim Pulley From Shafting

AN ELECTRIC motor was installed to drive the lineshaft in a pattern shop connected with a foundry. The lineshaft had previously been driven from the main shaft of an engine. The old driven pulley on the lineshaft was of the solid-rim type. To make room for a new driven pulley of the diameter required for the motor drive, it was necessary to remove the old pulley from the shaft. In order to do this, one of the shaft hangers had to be taken down.

The use of tackle for supporting the shaft in the absence of a hanger was avoided by first shifting the pulley close to the hanger and then suspending the shaft by means of a 1¼-in. hook bolt the upper end of which was inserted in a hole bored through a wooden stringer directly above the shaft, as shown in the accompanying illustration. The nut on the upper end of the bolt was tightened until the weight of the shaft was taken off the lower half of the bearing box in the hanger. The hanger was then taken down, the pulley slipped off the end of the shaft and the hanger restored to its place without disturbing the alignment of the shaft. A. J. DIXON.

St. Louis, Mo.



The shaft is supported by a hook bolt when the hanger is taken down to remove the pulley.

A Reader's Comment on Thawing Frozen Water Pipes by Electricity

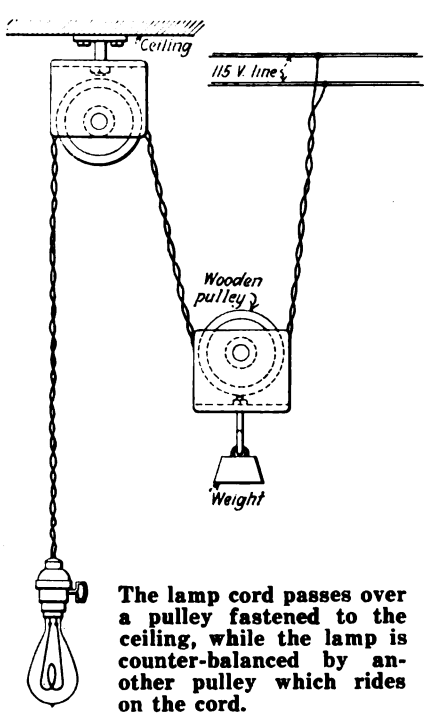
IN THE March issue of the INDUSTRIAL ENGINEER, page 161 appeared an article on "A Simple Method of Thawing Frozen Water Pipes by Electricity." Briefly, the plan was to strip the insulation from the end of a wire for a distance of about 6 in., fasten the wire to a stick, and then partly re-insulate the end by wrapping cloth around it after this cloth has been soaked in salt water to make it of low resisttance. The other end of the wire is then attached to the nearest lamp socket through an attachment plug and the cloth-wrapped end held against the pipe. This causes a high-resistance ground and as the current flows heats the pipe.

The ordinary lamp socket is fused for only 10 amp. and sometimes only for 6 amp., so that the maximum current that could be obtained in this way would be very small; in fact, so little that it would have no effect on any but very small sizes of pipe, smaller than any that would ordinarily be used around a plant in any exposed place. While the plan proposed might work in some cases, ordinarily more current would be required than is obtainable from a lamp socket.

Westfield, N. J. G. H. MCKELWAY.

Simple Method of Mounting an Extension Light

OF THE many ways of mounting an extension light the method described below is perhaps as simple as any. This method of mounting requires only two wooden pulleys, one



The lamp cord passes over a pulley fastened to the ceiling, while the lamp is counter-balanced by another pulley which rides on the cord.

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of which is fastened to the ceiling while the other rides on the lamp cord itself to counterbalance the weight of the lamp. It might seem at first that there would be an objection to running the lamp cord directly over the pulleys, because the bending and wear might be injurious to the cord and cause a short circuit. However, the cord on several extension lamps of this kind that have been used for the past four or five years shows less wear than in the case of most of the other devices, of which there are quite a number in use, including several which are on the market.

The extension devices which can be purchased of course take up less room, as they wind the cord on a reel and can therefore be mounted on the side of the wall or on a post. But some of them are not quite as convenient as they look and in addition are rather expensive. With the arrangement described here there is nothing except the lamp cord to get tangled and that is kept in place by the pulleys. If the pulleys are made fairly large, say 4 in. or 5 in. in diameter, the bending of the cord as it travels over the pulleys will not be injurious. Also, the strain on the cord is very light compared to what it is with some other devices. Care should be taken to provide the pulleys with a wide guiding strap or hanger, as shown in the illustration, so as to prevent the cord from running off the side of the pulleys.

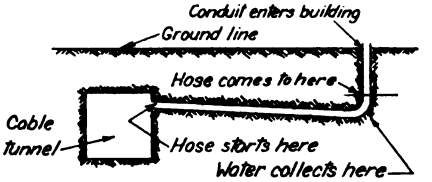
PHILIP E. BERNHOLZ.
East Orange, N. J.

Rubber Hose Used to Protect Wires in Conduit From Water

THE ACCOMPANYING sketch shows a simple method that was used to prevent water from shorting and grounding a 480-volt circuit which was laid in conduit. The duct line is of 2-in. Orangeburg fiber conduit and was put down without any protection or regard for drainage. The line runs from a cable tunnel to a building a short distance away.

Inasmuch as there was no drainage from the duct, sufficient water would frequently collect in it to make a short circuit between the wires and cause a good deal of trouble. As a cheap and easy way of remedying this trouble a piece of rubber hose, 1-in. inside diameter and long enough to reach from the tunnel to a short distance above the bend of the duct, was procured. The six wires in the duct were run through the hose and securely fastened and the hose then pulled into the duct.

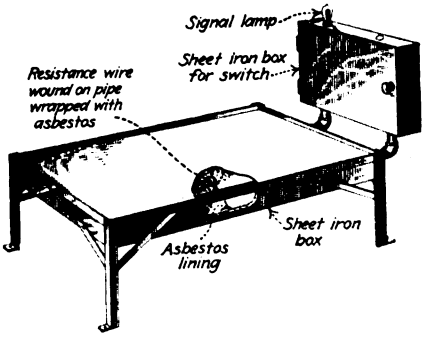
I realize that this method of overcoming the trouble may not be in accordance with all rules and regulations, but it served its purpose, for no further trouble has been experienced. Furthermore, it saved both time and money, which was an important consideration. F. G. F.
Ada, Okla.



The wires are encased in a piece of rubber hose, which protects them from water collecting in the conduit.

How to Build a Flat-Topped Electric Heater for Contact Drying

IN SOME manufacturing processes it is necessary to dry the work before performing the next operation. One example of this in the shoe industry is the drying of the soles before buffing. For this, one shoe factory uses the specially constructed, flat-topped electric heating device shown in the accompanying sketch. This is constructed with two large heating elements enclosed in a partially air-tight, heat-insulated sheet-iron box, supported by four angle-iron legs. All of the inside surfaces except the top of the box are heat-insulated from within by three ¼-in layers of asbestos. The 17-in. by 54-in. sheet-metal top which is made of No. 16 galvanized sheet and supported at the edges has a drying surface area of 918 sq. in. The heating elements consist of two 1-in. gas pipes 60 in. long wrapped with a layer of non-burn, sheet asbestos for insulating the coil of No. 12 Nichrome wire which is wound on the pipe the length of the containing box. This wire has a total resistance of 7 ohms, giving a current consumption of 16 amp. at 110 volts, a total of 1,760 watts. One end of the gas pipe is fastened to one end of the box while the other end passes through the opposite end and connects into a service box. The live portions of the elements do not touch any part of the box.



This electrical heater is used to dry shoe soles before buffing. The construction of the heating elements is explained in the accompanying item.

At the terminal ends of the coil a hole is drilled into each gas pipe and insulated with short porcelain tubes. The ends of the wire, insulated with asbestos tubing or insulating beads, are inserted through these tubes into the pipes and run inside the pipes to the service box where they connect to the switch.

In operation the temperature rises to 160 deg. F. at the working surface. The box is capable of drying 1,080 pairs of ladies shoes satisfactorily for good buffing in eight hours. Although this electric heating device has been in use for five years and operates eight hours per day except Sundays and holidays, the heating elements are still in good condition. ALBERT KOCHS.
Chief Engineer,
Hamilton Brown Shoe Co.,
St. Louis, Mo.

What to Do and What Not to Do When a Plating Generator Sparks

A PLATING dynamo of any appreciable size delivers, at times, current amounting to many hundreds or thousands of amperes. If there is sparking at the brushes, a rough commutator will be the result in a short time, which in turn will rapidly wear down the copper gauze brushes. Sparking should not be tolerated any length of time if it can possibly be avoided. When this trouble is encountered and it is not necessary to turn the commutator in a lathe, the best remedy is to remove all the brushes and their holders, drive the dynamo at full speed and proceed to smooth the commutator with a stone.

The best stone for this purpose is one of carborundum (very fine grain) measuring 4 in. long, 2 in. wide, and 1 in. thick. First mark this stone to correspond to the arc of the commutator and then grind

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it out on an emery wheel, so that the concave area fits as closely to the commutator as possible. The stone should be ground on its long edge to make it easy to handle.

If the surface of the commutator is lightly wiped with a piece of waste or cheese cloth soaked in kerosene, the copper dust will be removed and the stone will "bite" at once. The stone should be held firmly with both hands and pressed down hard till it cuts, shifting slowly from side to side across the commutator, but not following up and down in the grooves. It will be found that the stone will be copper-coated in a minute or two, but this can be removed with No. 1 or No. 0 glass paper. After a number of repeated attempts at smoothing the stone will cease to copper coat, as the commutator will become rough enough to throw off all the dust.

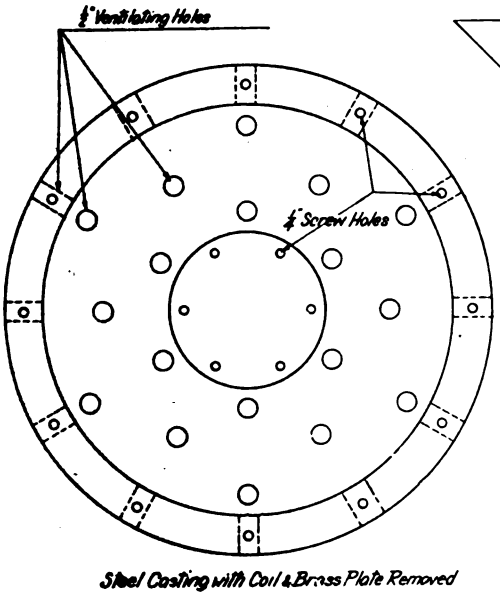
When the stone heats so that it is unbearable to the hands, simply allow it to cool off, perhaps outside the window, but do NOT USE WATER for this purpose. Continue to cut the surface of the commutator as hard as you can bear down on it, moving slowly sideways, until all grooves are smoothed down, which may take half an hour or more.

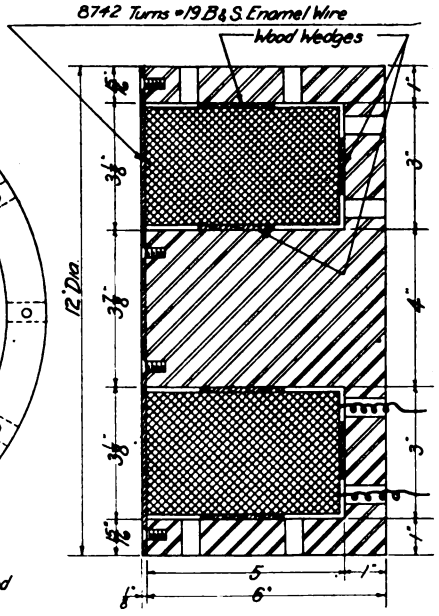
When nicely trued then lay a strip of No. 0 or No. 00 glass paper in the concavity of the stone and smooth the commutator till the roughness of the severe cutting has been eliminated. Fifteen or twenty-five strips may have to be used in this treatment. After some fifteen minutes or more a little motor oil should be applied to the glass paper or to the commutator. Then the surface of the copper will begin to smooth up rapidly and begin to look like new. When finished wipe the commutator and clean the holder pins and their insulators on the rocker arm of copper dust.

New gauze brushes may now be set into position. Stagger each successive set sideways from the preceding set, but do not allow them to bear down hard. Much of the trouble from sparking is due to copper brushes having a tension similar to that given carbon brushes. The former are good conductors while the latter are not, thus needing more tension. Copper gauze brushes properly staggered, with fairly light tension; a smooth commutator slightly smeared with vaseline; the rocker-arm set with the brushes slightly leading the neutral point; and the armature shaft having a little end play, will result in a sparkless and cool running plating dynamo.

To keep the commutator in good condition, clean it each morning with thin oil (such as "3 in 1"), and then apply a little vaseline. Heavy oil poured on the commutator, or the application of a greasy compound stick will cause poor contact and sparking if continued daily. When sparking is in full possession such applications are not "cures" but irritators and the operation described must eventually be performed.

New Britain, Conn. H. S. RICH.





Construction details of magnet for removing stray iron from coal or other materials.

How to Make a Magnet to Remove Stray Iron From Coal

EXCEPT to the man with a good technical education or to those who have made a special study of the subject, the construction of a lifting magnet is always a difficult problem. This is largely because the necessary data is hard to find even in the best handbooks and, when found, it often contains so many difficult formulas that it is hard for most of us to use it. The accompanying illustration shows a magnet which the writer had to design for cleaning coal on an 18-in. belt conveyor before the coal was put into Griffin mills to be ground to powder for use in cement kilns. The Griffin mills have a fine-mesh screen which is easily broken by bolts, nails, washers, or other pieces of iron commonly found in coal. This magnet by removing such stray pieces of iron has cut the screen consumption on eight Griffin mills over 60 per cent, and has paid for itself in less than two months.

The magnet is wound for 125-volt direct current and at that voltage takes approximately 1½ amp. The body is made of a soft steel casting finished as shown in the illustration, with a slight taper which allows the coil to be easily inserted and wedged in. The coil, which consists of 8,742 turns of No. 19 B. & S. gage enamel-insulated magnet wire, was wound on a spool and made of such size as to leave a ⅛-in. space all around between the coil and the iron. The coil was then insulated with two layers of strong cotton tape, half-lapped, and given two coats of shellac. When in place the coil is separated from the iron by ⅛-in. wooden wedges. This allows air to circulate around the coils and a number of ½-in. holes were bored as shown to provide thorough ventilation and cooling. After a 6-hour run the temperature of the coil was 50 deg. C. as shown by a thermometer held against the insulation through one of the ventilating holes. The leads are brought out through two of these holes and run through a fiber terminal block at the back of the magnet. A brass plate ⅛-in. thick holds the coil in place and is secured by eighteen ¼-in. by ½-in. flat-head brass screws. The magnet can be supported by one or more ring bolts, threaded in at the back, depending on the place where it has to be used and the angle at which it must be held. The cost of the magnet was about $70 in material and labor.

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No claim is made for perfection of design or high efficiency; likely a much better magnet could be made out of the same material, but it works satisfactorily. It will pick up 6-in. wire nails at a distance of 5 in., or a bar of iron 1 in. square and 12 in. long at a distance of 3 in. Some idea of its strength may be obtained from the fact that it will hold up a piece of 7-in. round shaft weighing 100 lbs. The ability to attract small pieces of iron at a distance of 4 or 5 in., is of course, the feature most useful to us, inasmuch as we had to mount the magnet 4 in. above the belt conveyor so as to allow the coal to pass underneath. It has now been in use for over six months and has given no trouble whatever. The only attention it needs is having the belt conveyor attendant scrape off the nails, washers, bolts, and so on, about once every hour. This is done with the hand and can be done safely without cutting off the power by using a working glove to save the fingers from cuts and also to provide against possible shock from grounds when the conveyor tunnel floor is damp.

J. H. GALLANT.

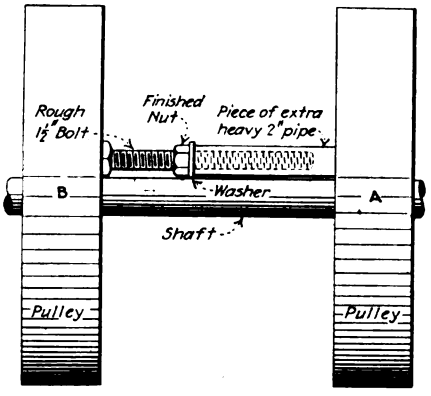
Canada Cement Co., Ltd.,
Belleville, Ont., Canada.

How a Tight Pulley Was Moved on Its Shaft

IT IS often hard to shift a pulley along a shaft, especially if it has been in place for some time. For this reason some methods which the writer has seen tried for moving tight pulleys may be interesting.

A solid-rim pulley on a countershaft resisted all efforts to move it on the shaft until the jack shown in the accompanying drawing was applied. The resistance was probably due to the slight annular elevations on the surface of the shaft under the set screws, aided by the rusted condition of the hub and shaft The jack consisted of a piece of 2-in. double-extra-heavy pipe, a 1½-in. rough bolt and finished nut, and a steel washer about ½ in. thick. The pulley *A* was clamped firmly to the shaft with the set screws. The set screws of pulley *B* were slacked off and the nut of the jack was tightened against the washer. By this means a powerful force was exerted against pulley *B*.

If a solid-rim pulley cannot be shifted along a shaft by ordinary means, and there is nothing to jack against, then the grip of the hub may be loosened by applying heat. This method was used in moving a 40-in. solid-rim pulley a distance of 20 in. along the shaft. An attempt was first made to drive the pulley with a heavy steel bar and sledge. After an hour's steady work the pulley had been shifted scarcely an inch. It was then decided to expand the hub by heating. Four gasoline blow torches were hung from the spokes of the pulley, two at each end, and their flames were allowed to play on the hub for half an hour. The hole in the hub had then been enlarged sufficiently to permit the pulley to be moved by merely butting the hub with the end of the bar.



A tight pulley can be moved along the shaft by means of a jack.
A second pulley, A, was firmly fastened on the shaft a short distance from the pulley to be moved. The jack was then placed between the two pulleys and tightened.

St. Louis, Mo. A. J. DIXON.

Sectional Short Circuit Caused Burn-out of Entire Coil in Series Transformer

IT IS well known, or should be, that the secondary of a series transformer should always be short-circuited before opening the circuit to any of the devices which it feeds. This is especially important on large loads, since with the secondary open the whole primary current flows as magnetizing current and besides causing a high secondary voltage, which is liable to puncture the insulation, a large drop is produced in the primary circuit by reason of the high counter-electromotive force of the primary, which is, of course, in series with the line.

One often reads in manufacturers' literature concerning "tub" constant-current, series transformers, that even in the event of a complete short-circuit of the secondary, its current will still be within the limits of reasonable regulation and will cause no harm, provided the primary voltage is not above its rated normal value. One is liable to naturally conclude that short-circuits are harmless to the transformers mentioned, but such is not always the case.

A few days (or nights, rather) ago, lightning struck on one of our series street circuits, and besides burning out 50 or more lamps, it went by the arresters and blew all of the fuses on our substation switchboard. It also caused a *sectional* short-circuit of the "tub" secondary, and this in turn burned out. This condition was possible because only a fraction of the turns were concerned, and still further helped by the fact that when the lamps burned out the line was opened. The coil contained about 400 turns and with 6.6 amp. (the rated secondary current) it produced about 2,640 amp. turns with which to "buck" the primary coil.

The short took place over just ¼, or 100 turns, which, therefore, had to carry (or attempt to carry) four times 6.6 amp., or 26.4 amp., in order to produce the required amp. turns. No wonder, then, that this section caused their burnout, too, thus destroying the whole coil. No harm was done to the primary coil, because the secondary was repelled hard up against the yoke of the magnetic circuit and was thus quite a distance from the primary coil. The circuit was opened later by a time switch, anyway, and beyond filling the station with smoke, no harm was done by the burnout of the coil.

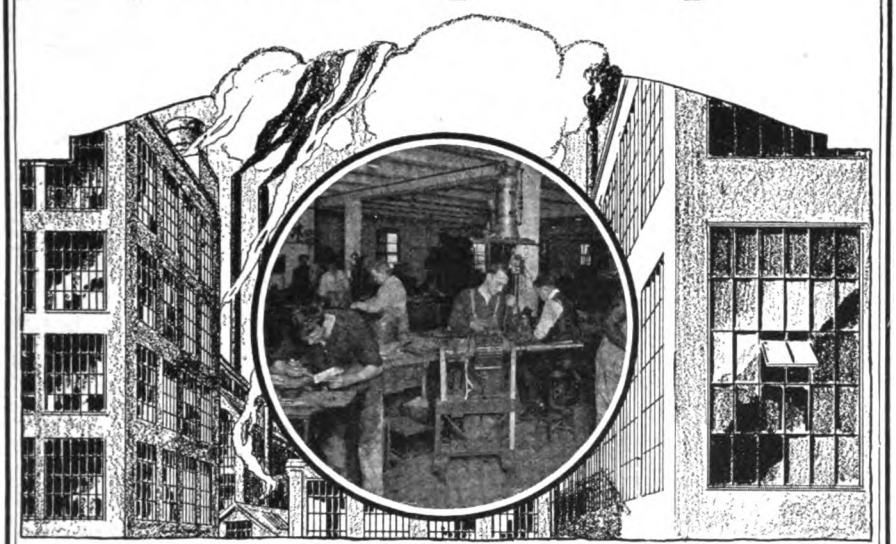
This experience shows that a "sectional short" can cause a burnout even though a complete short of the whole coil would not do so. This reasoning applies to series instrument transformers as well. The statements, therefore, that such devices can be short-circuited with impunity should be qualified by the conditions. Of course, it is the intention that shorts purposely made involve the whole winding, but as before said, one would conclude (without forethought) that since a short of the whole winding causes no harm, a short anywhere in the winding would likewise cause no harm. It is also possible for a short of a few turns to cause a burnout even when the secondary is normally closed, if the load is heavy.

HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

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In the Repair Shop



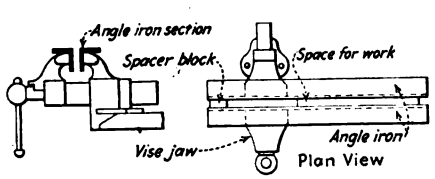
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Angle-Iron Extensions Enable Vise to Hold Large Parts

MANY repair shops could adopt to advantage the following method of holding long, irregular shaped pieces while working on them. In an iron-working shop where gratings, sheet-steel guards, wrought iron fence work and other similar large parts are worked on, the angle-iron extensions in the vise, as illustrated in the attached sketch, were devised to hold these sections while doing the necessary fitting and attaching of parts, such as hinges, bolting and riveting. These angle-iron extensions are placed between the vise jaws with a spacer block at one end, as shown in the sketch, equal to the width of the part being clamped at the opposite side of the vise. By using a spacer block slightly wider than the work the angle-iron clamps can be made to meet at the opposite end first and the vise jaws pulled up tight enough to hold the parts secure. When necessary the vise can be swiveled around to permit of clamping parts extending 3 or 4 ft. below the vise.

This extension is also applicable to sheet-iron and sheet steel work, as it is a simple device which can be easily prepared. G. A. LUERS.

Washington, D. C.

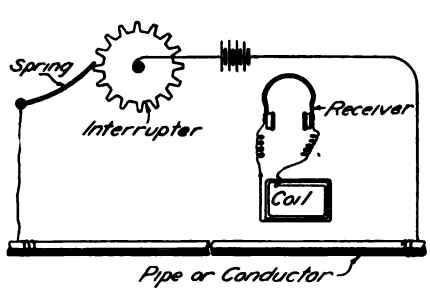


Wide extension jaws for a vise made from heavy angle iron and used to clamp pieces of unusual shape which ordinarily could not be caught in the bench vise.

Exploring Coils Simplify Work of Tracing Conductors

TRACING conductors, which includes all kinds of metallic piping as well as electric cables, is often difficult and accomplished only by considerable work and expense. A set of wireless telephone receivers connected to the proper exploring coil can, however, frequently be used to good advantage in such work with a resultant saving of time and expense. For example, about two years ago we were confronted with the problem of finding a T in an underground water main. Several short ditches were dug in order to locate it, but without success. Then an exploring coil about 4 ft. long and 3 ft. wide, wound with approximately fifty turns, was used while the pipe was excited with 500 volts alternating current and the joint located within a short time, although it was about 6 ft. beneath the ground.

While this may be one of the most practicable examples of using an exploring coil, I believe there are many other cases where it could be used. For instance, in long cables where it is undesirable to disturb or puncture the insulation as required for voltmeter tracing or where the cable or conductor is not accessible for making contact, like the neutral in a three-wire direct-current machine, in the bottom of the slot beneath other coils. It might also be used to tell if current is flowing in any alternating conductor where ammeter connection is impracticable or where there is leakage current through an iron structure or even to determine trouble with an alternating current motor; for instance, without disturbing connections, to find out whether the motor is taking current in all phases and whether the current in all phases is approximately the same. The exciting current required as well as the size of the exploring coil may vary greatly in extreme cases. From my own experience I find that the exploring coil should vary in size with the distance it is held away from the conductor. Thus it is possible to use a 1-in. coil when it can be held close to a small cable, as in the case where it is desired to pick one cable out of a bunch of similar cables, and as large as 3 ft. or more where the distance between the exploring coil and the pipe or other conductor is several feet, as in underground work. The exploring coil should be rectangular in shape, especially in the smaller sizes, so that one side of the coil can be placed parallel to the conductor to be traced. Any insulated, fine wire will do for the coil but as a rule the small coils should be wound with finer wire and with a larger number of turns, so as to get sufficient induced emf. About three sizes of coils will cover the entire range fairly well, using a 1-in. coil of 400 to 500 turns of No. 30 to No. 36 B. & S. wire for small work, a 4-in. by 8-in. coil of 500 turns for larger work and a 3-ft. coil wound with 40 to 100 turns of No. 20 to No. 30 B. & S. wire for underground work. The more turns a coil has the less exciting current is required. In all cases the ends of the coil should be connected to the receivers.



Here is a simple way of obtaining an interrupted current for testing with an exploring coil.

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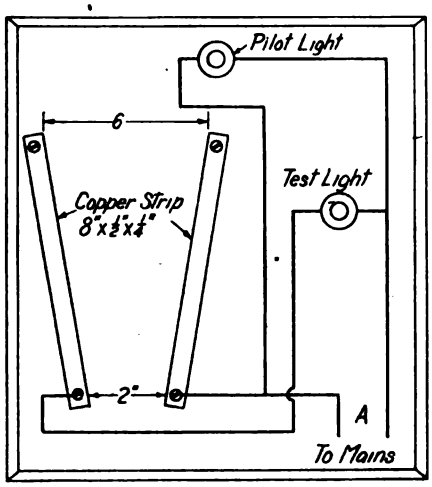
The section of piping or cable to be traced must, of course, be excited by a current of a frequency which is audible in the receivers. Such a current can easily be induced in any conductor in several ways. In an underground pipe one end of the pipe may prove sufficient for exciting it for some distance but, of course, if connections can be made at the two extreme ends by an outside circuit, it is far better. Where cables run through iron piping the exciting current must be sent through the pipe instead of the cables. For producing the exciting current a high-frequency generator is best but if such a machine is not available, current from a battery or other source may be used with an interrupter placed in the circuit so that the current flowing will be varied or interrupted and thus produce an audible noise. The accompanying illustration shows a simple and satisfactory method of obtaining an interrupted current suitable for testing purposes. As will be seen, the device employed for this purpose consists of a gear wheel on which a flat spring presses so as to snap from cog to cog and thus make and break the exciting current as the gear revolves.

PHILIP BERNHOLZ.

East Orange, N. J.

Inexpensive Board for Testing Lamps and Fuses

THE ACCOMPANYING diagram shows the arrangement of a board which I have found very convenient for testing lamps or any length or size of fuse. The material required for this board is inexpensive and comprises two ordinary porcelain lamp sockets, two pieces of copper strip 8 in. by ½ in. by ¼ in., and some No. 14 wire. The copper strips should be screwed to the board 6 in. apart at the top and 2 in. apart at the bottom. Where the wires are connected to the copper strip it is advisable to use end terminals of the flag type, screwed down tight to avoid the possibility of sparking or heating. The test lamp is in series with the strips and when a fuse is placed between them the lamp will light, provided the fuse is in good condition. The pilot light may be left out if the board is in a well-lighted position, but I think that it is advisable to use a pilot light inasmuch as it always shows whether current is flowing through the board.

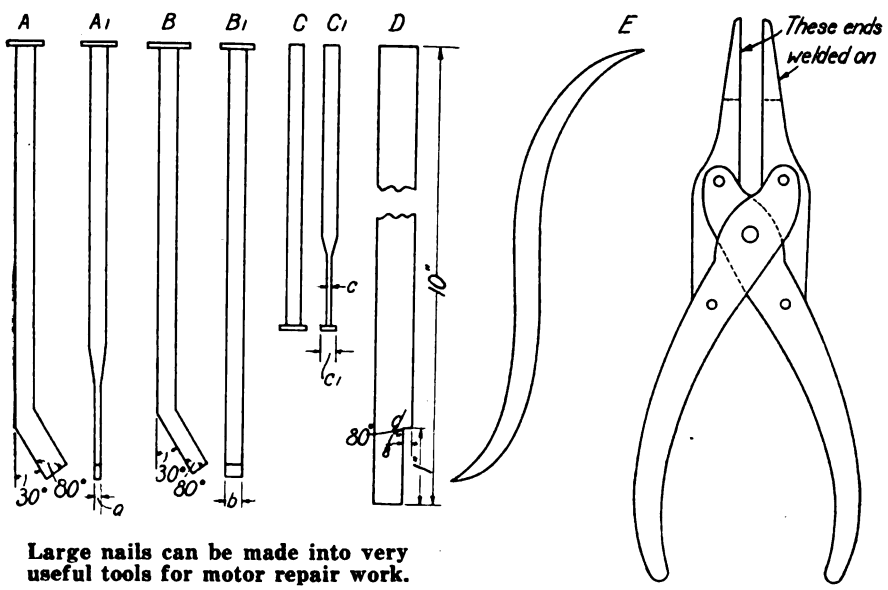


Arrangement of a handy board for testing lamps and fuses.

A single- or double-throw single-pole knife switch may be inserted at *A* if it is desired to open the circuit of the board when not in use. If series lamps, or lamps of half the ordinary voltage are used in the factory, two sockets in series may be used in place of the single test light, and when only one socket is required for testing, a 3-amp. fuse may be inserted in the other.

DONALD L. HOARE.

New York City.



Large nails can be made into very useful tools for motor repair work.

Easily Made Tools for the Motor Repairman

THE ACCOMPANYING sketch shows a few easily made tools which I have found to be very useful on motor repair jobs. The first three, *A*, *B* and *C*, can be made in a few minutes from 6-in. and 4-in. wire nails with a hammer and file.

The tool shown at *A* is for removing wooden wedges from small motors, 5 or 10 hp., with semi-closed slots. About one inch of the nail is bent at an angle of 30 degrees and flattened out with the hammer to approximately the thickness required; it can afterward be finished with a file. The thickness of the driving blade *a* must be such that it will just pass freely between the overhanging tips of the armature teeth. An angle of about 80 deg. has been found best to prevent tool from slipping off the wedge when being driven with the hammer. The tool *B* is made much the same as *A* except that the thickness of *b* of the driving blade is made greater, as the tool is intended for removing wedges from open slots. Tool *C* is made from a 4-in. or 5-in. nail, and is used for packing wires snugly in semi-closed slots. The nail is filed flat next to the head and is left just thick enough to slip easily between the overhanging tips of the armature teeth; the head is narrowed down so that it will just move freely inside the slot insulation. When two or more wires are placed in the slot a piece of tough fishpaper the width of the head of the tool is placed on them to protect the insulation from abrasion and the wires may be packed by gently tapping the tool with a hammer, or even by hand pressure. The tool *D* is for driving in wooden wedges. It can be made as shown in the sketch by filing a piece of ½ in. key steel or an old rotor bar. It can be used for driving wedges either on a stator or on a wound rotor; it is meant for use only after the wedge has been driven in flush with the end of the coils or of the rotor bars. At *d* the tool should be filed in to an angle of about 80 deg. to prevent slipping off

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the wedge. When driving, the thin part of the tool which is kept over the wedge holds the latter down against the coils or bars and prevents it from buckling and breaking. The dimensions given for these tools are approximate, and they can and should be fashioned to suit individual needs.

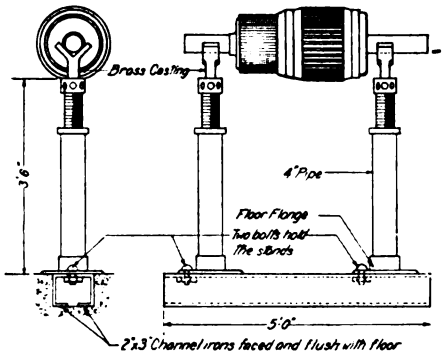
At *E* is shown a small cotter pin extractor with one end flat and one end round and tapered to a point. This makes as good a taping hook as can be found. The pliers shown in the last sketch cannot be bought as illustrated, so far as the writer knows. They are made out of an old pair of 6-in. Bernard parallel pliers by welding about one inch on the ends. When wound with one layer of friction tape they make a very handy tool for getting formed coils into the slots. Formed coils are often more or less twisted, and can seldom be put in without some twisting and pounding. With the help of these pliers, the flat points of which are thin enough to slip in between coils, it is possible to hold and pull a twisted coil parallel to the slot and thus put it in without cutting the insulation on the corner of the slot, the point where it is most often injured. Likewise as the jaws of the pliers are parallel and taped they will not injure the coils.

J H. GALLANT.

Canada Cement Co., Limited,
Belleville, Ont.

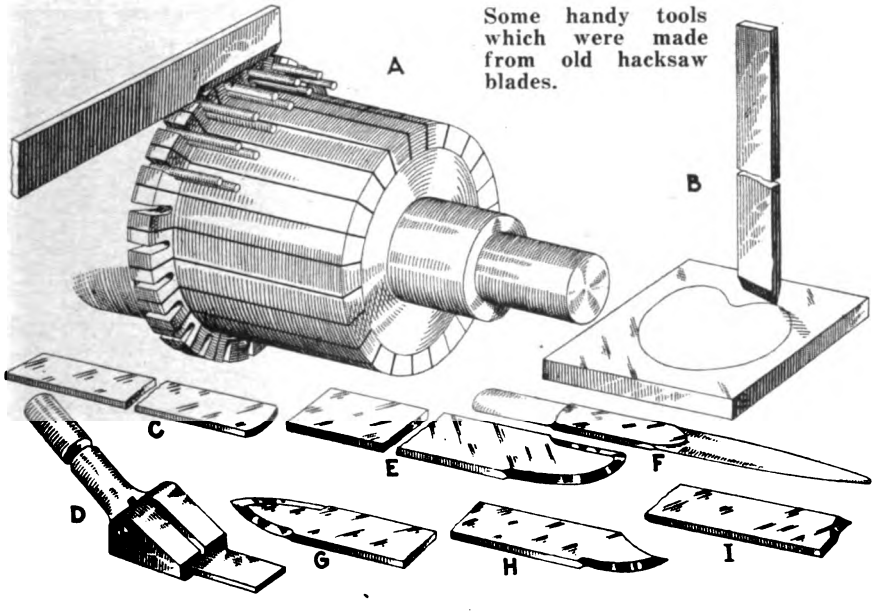
Adjustable Support for Rotors Facilitates Winding

USE OF an adjustable stand to support rotors while rewinding them has greatly facilitated this work in the repair shop of the Old Dominion Copper Company. The accompanying illustration shows a support which was made entirely of material available around the shop, with the exception of the brass tops which were cast for the job. As is shown, the height at which the rotor is supported can be adjusted by means of the screws. The distance between the legs is varied by sliding one of the legs along the channel-iron base. It has been found that even a few inches difference in the height of a rotor which is being rewound may add much to the comfort of the winder and the speed at which he can do the work. As this work is often of an emergency nature opportunities to speed it up should not be overlooked. The ease of turning the rotor to a new position is another advantage over using a bench while winding. Also, a rotor wound in this way is in no danger of injuring the coils when turning it as might happen if it were lying on a bench. STEPHEN TILLMAN.



Convenience and speed of winding are greater with an adjustable rotor support like this.

Chief Electrician,
Old Dominion Copper Co.,
Globe, Ariz.



Some handy tools which were made from old hacksaw blades.

Useful Tools Made From Old Hacksaw Blades

IN EVERY shop there is usually a lot of broken or worn-out hacksaw blades which will make handy tools. They need only to be ground to shape and, if they are too hard, have their temper drawn. For use in the electrical repair shop, blades ground sharp make good tools for cutting the ends of conductors at the commutator as shown in drawing *A*. The thinness of the edge makes it cut with light blows of a hammer, so that the commutator bars are not knocked down. Some of the other shapes shown may be used to clean surfaces, to skin wire, and to do general service in the kit.

For the machine shop large blades ground like *C* make good single- and double-end scrapers. These blades are fine for light work and especially for removing accumulations from the ways of machines which have been idle for a time. Sometimes short blades can be put into a holder like *D* to good advantage.

To make a tool useful to a pattern maker, take a power hack-saw blade, grind the teeth off and shape the end like *E*, sharpening it all the way around. This makes a good knife for reaching inaccessible places around the pattern. At *B* is a blade ground like a skew chisel and used for tracing lines for inlay work. By holding the upper end of the chisel with one hand and tapping it with a hammer one can work out any shape. At *F* is a double-ended palette knife good for mixing or spreading color, glue, putty or plaster of paris. If the blade is ground thin enough to have a good spring it is excellent for palette knife painting.

For the drafting room, *G* is a light blade from a band frame with the teeth ground off, sharpened on each edge for sharpening pencils; cutting paper and scratching out ink. At *H* is a better point for opening up the centers of letters such as *o*, *e* and *a* when they clog and also for sharpening corners and intersections of lines. At *I* is a shape for cutting along a straight edge. Only a small portion of the blade is sharp; the rest is left dull so that it will not spoil the straight edges.

Sometimes it is convenient to grind one of these forms on each end of the blade. If a handle is desired it can be made by wrapping the blade with electrician's tape and giving it a coat of shellac. Many prefer the flat blade, however, as it will not roll.

Detroit, Mich. NELSON HALL.

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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Flexibility of Movement by Either Hand or Tractor Increases Utility of a Truck for Shop Haulage

IN ANY material handling system, the units of equipment are more effective if flexible. For this reason whenever material handling equipment is so constructed that it can be moved both by hand or by other devices, it is usually of greater usefulness in the shop. One such example is the special two-wheeled box truck, shown in the accompanying illustration, of which many are used in an automobile plant. Each of these trucks has a special casting fitted on the front as shown. A special handle with a wheel and a pivot point may be fitted into this and by pushing down on the handle made to support the front end on the wheel instead of on the leg, as shown here, and the trucks can be pulled by hand. Also, this special casting fits into a coupling which fastens these box trucks together so that they may be used as trailers, in a train. Here one tractor makes regular 30-minute runs between the rough stock room and the machine shop. Material handling on a regular schedule such as this does much to prevent many tie-ups in transportation.

Frequently it is feasible to make a truck or container which may be handled in a third way. For example, in this instance the side pieces of the box truck are extended at the end in such a way that they may be lifted by a four-chain sling and an overhead crane, thus adding to the flexibility of the unit. Another plant has designed its containers so that they may be moved by hand, by power or hand-lift trucks or by crane. The skid is provided with rings at each corner for lifting by the crane and with wheels so that it may be pushed about.

Trucks that may be moved by hand, or by tractor or crane increase the ease and speed of movement of materials.

One of the objections to stationary trucks is that they cannot be moved without the tractor. Men on production do not want to wait. Here the box truck can easily be moved by a simple pivoted handle and wheel. For long hauls the trucks are coupled up into trains hauled by an electric tractor. Also with extensions on the side pieces, as here, the crane can pick one truck out of a group with a sling if it should become necessary to store a number of trucks together.

Signal Board to Notify Move Men of Loads Ready or Empty Trailers Wanted

ONE problem which must always be considered in any inter- or intra-departmental haulage plan is that of making some provision for signaling to the move men when loaded trucks and trailers are ready to be moved. This is particularly true where loads are ready intermittently at the various stations. This problem was one of the first encountered when a tractor-trailer installation was placed in the freight house of the Norfolk and Western Railroad at Roanoke, Va. Here an early problem was to devise some method whereby loaded trailers, which would be placed unexpectedly at a point on the platform out of the usual path of the tractor travel, would be hauled away so as to avoid congestion. In order to call a tractor to one of these points it was necessary at first to send a man to hunt until he found the first available tractor crew. This was unsatisfactory.

To remedy this the electrical department worked out a simple and effective system of signal lights to notify the tractor crews automatically when and where their services were required. A battery of green and red electric lights, with a light of each color placed by the side of a set of numerals, each of which designates a main division of a platform, was mounted on a board where the tractors in their regular duties pass it on each trip. A red light means that loaded trailers are ready to be moved and the number beside the red light indicates where the loads are to be found. A green light beside the numeral indicates that empty trailers are needed at the point des-



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ignated by the respective numeral. A glance at the board to see which lights are on tells the tractor crew where empty trailers are needed and where loaded trailers are waiting to be hauled away. The tractor crew is then able to take either a train of empty trailers to the spot where it is required or go with the tractor and haul away a loaded train.

Each pair of lights is wired to switch boxes, with a button for red lights and another for green lights, located on prominent posts along the platform in the sections denoted by the corresponding numerals and so are convenient to the checkers supervising the loading or unloading of freight cars. A pilot light shows the checker what signal he has set. As soon as the tractor crew reports to the checker in response to signal, he switches off the button so that another tractor crew will not report on the same signal. The pilot light makes it less likely that he will forget to turn the lights off than if he used an "on" and "off" indicator. In addition a master re-set switch controls the entire system so that the foremen during the lunch hour or after the day's work can extinguish all the signal lights from a central point.

Protecting Truck Platforms From the Heat of Hot Forgings by a Special Box Skid

ONE OF the biggest problems in connection with the operation of either electric storage battery or hand elevating-platform trucks is in the choice of the most effective skid. This was solved in one plant by the special box skid shown in the accompanying illustration. Here the problem was to handle hot forgings. The box skid is made up of heavy plate and angles as shown. The hot forgings, however, would warp an ordinary plate bottom to this box skid. The heat also would be transferred through to the steel platform of the elevating trucks and if it was necessary to haul the load any distance might warp it also.

To overcome this difficulty steel tubes, open at the end, were used in the bottom as shown. By the circulation of air through these the heat was dissipated sufficiently so that it did not affect the electric truck. The tubes, also, support the plate-steel bottom of the box skid.

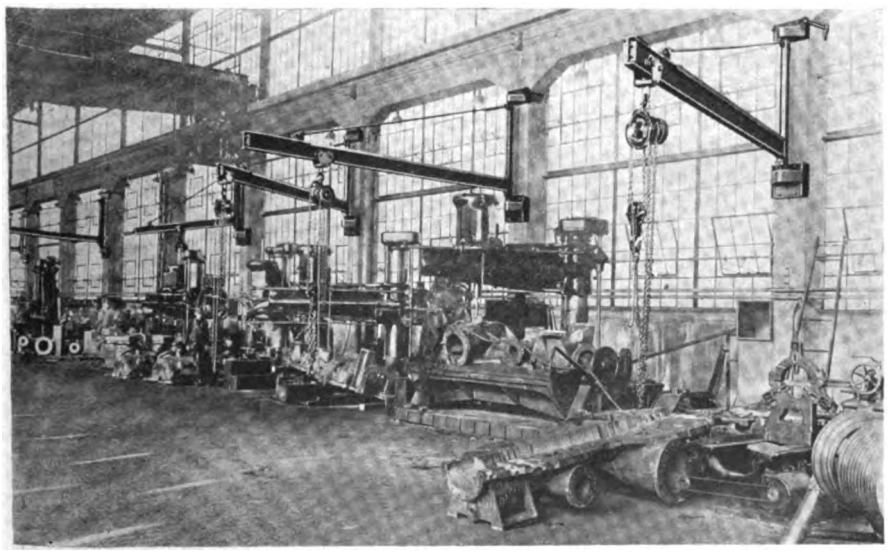


Hot forgings are handled by this truck skid without danger of warping the platform of the truck.

By attaching these tubes to the bottom of the box skid the heat from the hot forgings is carried away so that it is not transferred to the platform of the truck. This truck installation in a large forging plant was made by The Elwell-Parker Electric Company, Cleveland, Ohio. One man with a truck of this sort can handle loads up to 4,000 lbs. at a rate of about 6 miles an hour.

Swinging Jib Cranes Relieve the Traveling Crane of Miscellaneous Handling

ONE OF the easiest ways of tying up an overhead traveling crane for long periods is to require it to do the handling of large pieces to and from the machines or during assembly. One of the prime purposes of a traveling crane is to lift and carry heavy loads for some distance, instead of making a short lift or an adjustment. Where there is much of this work, it is often economical to add jib service cranes (Whiting Corporation, Harvey, Ill.) as shown in the accompanying illustration. These are attached to the wall and the boom swings around over the machine and covers considerable floor area. These are made in capacities of ½ to 2 tons, for ordinary service. The I-beam jibs carry trolleys which support chain blocks or air or electric hoists. Where work is moved frequently, on or off the machines, it usually pays to use a power-driven hoist.



Service jib cranes handle work to and from machines instead of waiting for the overhead traveling crane.

The machines in this engine-building shop do not have to take their turn in waiting for the overhead traveling crane as each machine is served by its individual hoist. Similar equipment can be used to the same advantage in assembling heavy machinery and often in stock rooms handling heavy parts. This equipment is out of the way and does not interfere with the regular operation of the traveling crane. Also the operator of the machine can use it without assistance.

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Operation and Management of the

Medium-Sized Plant

Was the Main Topic Discussed at the Meeting of the Society of Industrial Engineers at Cincinnati, April 18 to 20

By FRANK E. GOODING
Associate Editor, Industrial Engineer

DUE TO the changing industrial conditions it was quite fitting that the major subject which was discussed at the Tenth National Convention of the Society of Industrial Engineers in Cincinnati, Ohio, on April 18, 19 and 20, was "Effective Management for the Moderate-Sized Plant." Particular emphasis was given to the problems of the moderate-sized plant, that is, those employing between 20 and 500 men. In times past, most of the attention to the control and operation of management and production has been devoted to what has been commonly called the larger plants. The wealth of our country lies in the development of our natural resources. It is the work of the minds of the management to make more effective the work, methods and processes so that the men can effectively increase production from the effort put in. As the large plants produce about two-thirds of the total value of manufactured products and employ about half of the men, while the smaller plants produce one-third of this total and also employ approximately the other half of the workers, it is easily seen that there are wide opportunities for improved management and operation to get the value of production per man more nearly equal in large and small plants. Thus it was fitting that Joseph W. Roe, president of the Society, took as his subject, "The Need of Management Methods in the Moderate-sized Plant." In part, Mr. Roe said:

"Out of 290,105 manufacturing establishments reported by the United States Census in 1919, there were only 1,021 or less than 0.4 per cent, which employed more than 1,000 wage earners; and only 2,770, or less than 1 per cent, employing over 500. There were 235,884, or 81.3 per cent which employed 20 or under, but they represented all told, only 10.3 per cent of the wage earners, and an even smaller percentage of the production. The remaining plants, namely those employing between 20 and 500 wage earners, number 51,451 or 17.7 per cent of the total, and represent 50.1 per cent of the total wage earners.

"The advantage of the large plant over the small one lies chiefly in the field of purchases and sales. In actual production the small plant can frequently compete with the large one on even or better terms. Certain industries are by nature monopolies and under proper regulation should be operated as such. In others, such as refineries, steel and flour mills, production is more economical when carried out on a large scale. There remains, however, a large field of industries where quantity production is not essential and quality is important. In this field the small plant is able to compete and has certain distinct advantages.

"(*a*) To a large degree, the actual managers of the small plants are the owners, with a keen and vital interest in the operation. They can act and adjust their policies quickly to changed conditions. (*b*) The owners and the employed force are in close daily contact, and so know and understand each other. (*c*) The influence of a keen, magnetic personality at the top can permeate the whole plant, and not have to filter through a set of officials to reach the workmen. Generally the small plant has less labor trouble. (*d*) The operations of the small firm are usually confined to one plant and may be carried on by direct personal contact, with freedom from red tape and internal correspondence. (*e*) Because of the above, the overhead is frequently less than in the large plant. (*f*) It is easier to maintain the spirit and atmosphere of quality.

"Something is sacrificed from practically all of the above elements with increasing growth. Growth usually comes by development into manufacturing as distinct from building or special order work. It is hard, however, for the small firm to resist pressure from customers and salesmen for special modifications in design, and for promises of delivery which can only be kept by an endless procession of rush orders, which wreck any consistent production program. But growth as a rule depends on concentration upon such a program and on standardization of product. Growth depends on wise provision for extension of both plant and organization. Provision for future physical growth is more common than for development of the organization. More owners can show you where they plan to put their next building, than can tell you who is in training to head departments they plan to add in the next few years. The personnel of the small plant should be chosen with growth in mind. The big plant can get and pay for a big man who has already arrived. The small plant must raise him. The small growing concern which selects, trains and coordinates its force into a smoothly working unit is building up an asset which gives it an immense advantage over any new competitor, however large."

One important difference between the large and small plant, as pointed out at one of the meetings, was that the small plant conserves material at the expense of time while the large plant conserves time often at the expense of material.

In the Friday afternoon meeting, particular emphasis was given to the subject of "Health and Industry," under the direction of the Industrial Health Conservatory Laboratories, of which Dr. Carey P. McCord is director. One of the discussions took up the subject of "Lighting—Good and Bad." The speaker pointed out that it had been established that good lighting had increased production 10 per cent. Also, that about 25 per cent of products were made under artificial light and that a large percentage of poor quality work could be chargeable to bad lighting. It has also been shown that at least 20 per cent of preventable accidents are due to insufficient illumination. This is considerable improvement because, not many years ago, at least 25 per cent of accidents were due to the same reason.

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Servicing Industrial Transmission Belts

(Continued from page 256)

high speed, metallic fasteners or laces work satisfactorily.

Methods and Materials Used in Dressing Belts

Manufacturers and belt users do not always agree as to the proper belt dressing to apply. Each manufacturer recommends certain dressings for his belts and these should be considered. Belt dressings are applied, in general, for two purposes: Either to soften the belt and lubricate the fibers to reduce wear due to the continual bending action as it goes over the pulley and straightens out, or, to prevent slipping. For leather belts the manufacturer's dressings usually consist of animal greases or oils similar to those used in currying belts during manufacture. (Currying is a process for replacing in the belt the natural, animal oils which make a belt soft and pliable.) Belts are dried out by the action of the air, get hard and crack. Natural, animal oils are probably the best lubricants for these fibers as they are most near to the natural lubricant in the original hide. Belts which have stood idle for some time should be dressed to soften them up before placing back in use. Double- and three-ply leather belts should be treated on the outside as well as on the side next to the pulley when dressed.

One of the more common of the practical shop-man's applications consists of two parts of beef tallow (inedible) mixed with one part of cod liver oil. The oil is added to the melted tallow after it has cooled slightly and stirred until cold. It is applied with a light brush, but care must be taken not to use more than the belt will absorb. Neatsfoot oil is also often used in working dried-out belts into shape.

Belts used in dusty, dirty places or where dressings have been used in excess and have dried or caked on the surface of the belt, should be cleaned before dressing. Leather belts may be cleaned by washing or scrubbing with a brush in a cleaning mixture composed of two parts of gasoline or naphtha and one part of turpentine. This mixture must not be used on rubber or Balata belts. Also, a high-grade naphtha or gasoline must be used as low-grades of these oils leave the belt greasy. This softens the dirt so that it can be scraped off with any metal straight-edge not sharp enough to cut. If one treatment is not enough it should be repeated and the belt dried before applying the dressing. Methods of cleaning belts when they are very dirty or oily will be described in the next article.

Rubber or Balata belts may be treated by the preparations recommended by the manufacturers of the belts, or, by a few drops of castor oil applied to the pulley when revolving and allowed to spread from it onto the belt. A light application of raw linseed or castor oil may be used on canvas belts. Woven cotton and camel's-hair belts, particularly if specially treated, should be dressed as recommended by the manufacturer.

One of the greatest dangers in the use of belt dressings lies in their use to excess. If more dressing is given than the belt can absorb, the surplus remains on the surface of the belt and collects dust. Sometimes it works up into a lump on the belt or the pulley. In such cases, clean the belt as described, scrape off the pulley and re-treat, using less dressing. Careful and proper dressing does much to prolong the life of belts.

Particular caution must be given against using mineral oil dressings, especially on rubber or Balata belts, and rosin or laundry soap as dressings or to stop slipping. Rubber, Balata and untreated canvas belts are easily ruined by mineral oils. It also decreases the effectiveness of leather belts, but they can be cleaned and treated to make them almost as good as new.

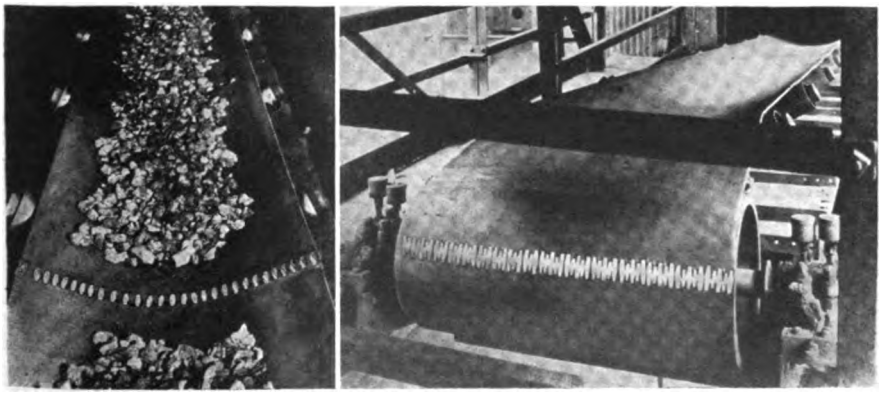
There is a number of dressings on the market which in addition to treating or lubricating the fibers of the belt, also prevent slippage on the pulley even though the belt is run quite slack. Care, however, should be exercised to see that an excess is not used.

Records Which May Be Used for Keeping Track of Belts

Many concerns little appreciate the advantages which come from emphasizing the importance of proper inspection and supervision of belt systems. In many instances belt maintenance costs have been cut in half through proper attention. This saving is small, however, compared to the much larger economies possible due to decreased idleness necessary for belts to be repaired. These savings often amount to several times the cost of making the belt repair.

An important part of any inspection routine is proper records of what has been done. Without these, belt inspection is a hit-and-miss proposition. Adequate records also point out any belts which are not up to quality. Without some such records, one is reproduced with this article, it is almost impossible to make a real comparison of two kinds or grades of belts. Even then the work on other operating conditions must be comparable. After a belting system is once placed in first class shape it is much easier to keep it in condition.

A later article in this series, which will appear in an early issue, will take up the belt reclamation which may be done in an industrial plant. The author wishes to acknowledge special assistance from Louis W. Arny, secretary, The Leather Belting Exchange, J. R. Hopkins, Chicago Belting Company, R. C. Moore, Chas. A. Schieren Company, M. W. Edgar,



Here two types of steel lacings are shown on a conveyor belt.

The belt at the right is joined by a staggered lacing made in short lengths so that it does not interfere with the cupping of the conveyor belt. The belt at the left has a somewhat different type of lacing in that each is individual. Both of these are Bristol metallic lacings.

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Detroit Belt Lacer Company, and R. H. Whitney, The B. F. Goodrich Rubber Company, in the preparation of this and other articles which have appeared in this series on belts for industrial purposes.

EDITOR'S NOTE: Acknowledgement is made to the following companies for assisting in furnishing information and photographs for this and the other articles which will follow in this series: The Leather Belting Exchange, 119 S. Fourth St., Philadelphia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; Birdsboro Foundry & Machine Co., Birdsboro, Pa.; The Bristol Co., Waterbury, Conn.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Belt Lacer Co., Detroit, Mich.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co., Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Goodyear Tire & Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Indianapolis, Ind.; Imperial Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; New York Rubber Co., New York, N. Y.; J. E. Rhoads & Sons, Wilmington, Del.; W. H. Salisbury & Co., Chicago, Ill.; Chas. A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Machinery & Supply Co., New York, N. Y.; The Taylor Belting Co., Indianapolis, Ind.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

American Injector Company, Detroit, Mich.—A small booklet describes "Agrilite" bearing metal. This is claimed to be a self-lubricating metal with high tensile strength and hardness to withstand bearing pressure, made of bronze alloy consisting of copper, tin and lead. The results of various tests of this metal are included as well as letters from numerous users.

Detroit Belt Lacer Company, Detroit, Mich.—Folders describe the "Detroit" closing machine for lacing belts. This is a flexible steel belt lacing with staggered hooks. These are closed by a special bench machine or by a piece of equipment which fits into a vise.

Sampson Axcess System, Lynn, Mass.—Catalog 2 describes the Axcess ceiling, wall and bench fixtures as well as stationary lighting attachments for machines. This is a special method of getting the lamp and its reflector placed in the proper position for work without interfering with the operator.

The Lester Company, Fayetteville, N. Y.—A small folder describes an aluminum solder and flux for soldering aluminum. Operating instructions are given to show how it is used.

The United States Graphite Company, Saginaw, Mich.—Special booklets and catalogs describe the various grades of graphite paint for different types of protective work. Several pages are devoted to a discussion as to why graphite paint should be used for protective coatings. Among the items discussed are the covering power, the estimation of the quantity needed, and specifications for graphite painting.

McGill Manufacturing Company, Valparaiso, Ind.—A small folder describes the new thumb-switch portable lamp guard. This guard has a hardwood handle, a hook and a reflector. The switch is operated by the thumb while in the natural position to hold the lamp.

Driver-Harris Company, Harrison, N. J.—Data book R-23 entitled "Alloys for Electrical Resistance" devotes over 50 pages to the description of the various Nichrome and other alloy wires for electrical resistance. Over half of this book is devoted to tables and charts as well as curves giving technical data on the various resistance wires. Among the subjects covered are: temperature resistance curves, current temperature characteristics, the resistance of the various wires, and much other useful data.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Recent literature describes the new automatic auto-starter for squirrel-cage induction motors. This can be adapted for remote push-button control or for full automatic operation, without the presence of an operator. The control relay is given a definite time limit by means of a dash pot so that the time of starting a motor can be adjusted for any period up to a maximum of 15 seconds.

The Thompson Electric Company, 226 St. Clair Avenue N. E., Cleveland, Ohio—A small folder describes "Glasbrite," a chemical cleaner for dry cleaning and polishing in one operation reflectors, windows and skylights for factories, foundries, and other industrial plants.

Robertson Chemical Company, 9808 Meech Avenue, Cleveland, Ohio—A 24-page catalog is devoted to the Walpole electric insulating compounds. This book not only describes the various liquid, plastic and solid insulating compounds, but also gives instructions and directions for their use.

J. E. Rhoads & Sons, Wilmington, Del. A 64-page pocket-size booklet entitled "Belt User's Book" gives rules, suggestions and other information for belt users. Particular attention is given to splicing, lacing, and other similar treatment of leather belts.

Flexible Steel Lacing Company, 4607-31 Lexington St., Chicago, Ill.—A 72-page pocket-size booklet entitled "Short Cuts to Power Transmission," which is a handbook for belt users, describes the various types of belts, their care and the method of lacing. Particular emphasis is placed upon the use of the various sizes of "Alligator" flexible steel belt lacing. A large amount of belt users' information is included in this catalog.

The Esterline-Angus Company, Indianapolis, Ind.—Bulletin No. 223, which is one of a series of monthly bulletins, issued by the company, is entitled "Some Things Being Done With Graphic Instruments." This Bulletin illustrates a number of graphic instrument installations and shows what uses are being made of them in various industries and commercial plants.

United States Rubber Company, 1790 Broadway, New York City—A 70-page pocket-size booklet entitled "Belting" gives valuable information to the belt user on rubber and canvass belts. This is divided into three sections, which take up transmission belting, conveyor belting and elevator belting. In addition, a number of pages is devoted to miscellaneous tables of value to belt users.

Cling-Surface Company, 1032 Niagara Street, Buffalo, N. Y.—A group of folders describes the advantages and applications of "Cling-Surface" belt preservative in various lines of industrial plants.

The Borden Company, Warren, Trumbull County, Ohio—Catalog 16 describes the Beaver line of pipe cutting and threading tools. With these dies threads for several different sizes of pipe, for example, on one die head threads for 1 in., 1¼ in., 1½ in. and 2-in. pipe are cut without changing the dies or bushings. In addition, a special method of cutting a tapered thread which is explained in this catalog gives, it is claimed, much easier operating conditions so that it is stated one man can thread 8-in. pipe.

L. B. Allen Company, Inc., 4519-29 North Lincoln Street, Chicago, Ill.—A folder describes the Allen gas soldering tool with assorted tips, as well as a line of gas solder furnaces.

E. B. Bronson and Company, Blue Island, Ill.—Special folders describe the Bronson electric lantern, operated from a battery, for watchman, railroad and other similar service. This lantern is made in six different types, each of which is described in this folder. Additional literature describes the Bronson rechargeable storage battery and recharge rack for use instead of dry cells in this electric lantern.

Rohne Electric Company, Inc., Minneapolis, Minn.—A folder describes the "Sta-Warm" soldering iron. In this, the switch for the current is placed in the handle. The advantages claimed for this iron are described in the folder.

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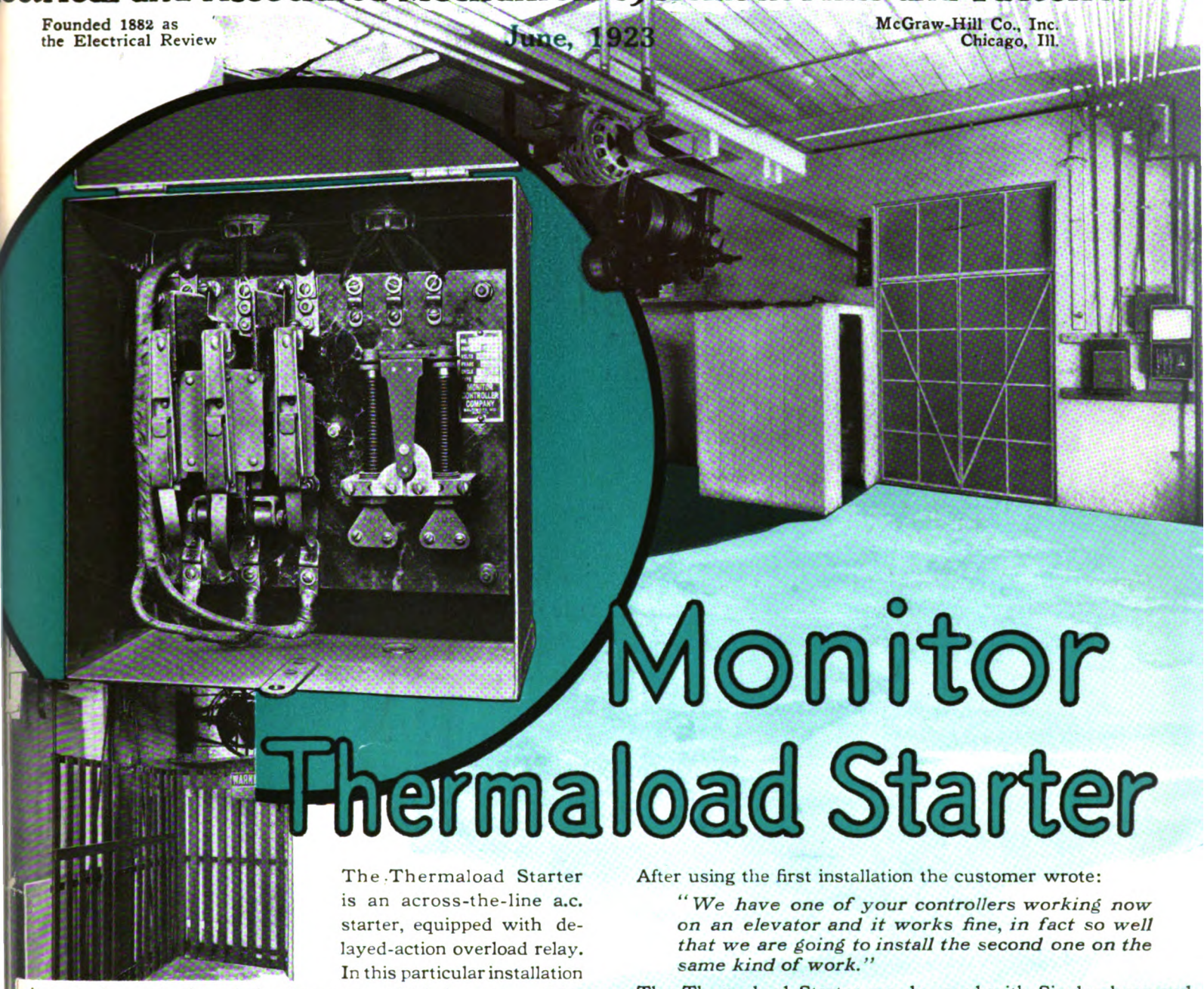
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

June, 1923

McGraw-Hill Co., Inc. Chicago, Ill.



Monitor Thermaload Starter

The Thermaload Starter is an across-the-line a.c. starter, equipped with delayed-action overload relay. In this particular installation it controls a polyphase induction motor which is connected by belt to elevator machine. The elevator is controlled by shipper rope, and on each floor there is a Monitor push-button station which permits the operator to stop the motor when he finishes using the elevator.

After using the first installation the customer wrote:

"We have one of your controllers working now on an elevator and it works fine, in fact so well that we are going to install the second one on the same kind of work."

The Thermaload Starter can be used with Single-phase and Polyphase Induction Motors up to 5 hp. 110 volts, 10 hp. 220-550 volts. It provides full voltage, full current and full-torque start.

Ask for copy of bulletin No. 101 giving full details.

Monitor Controller Company

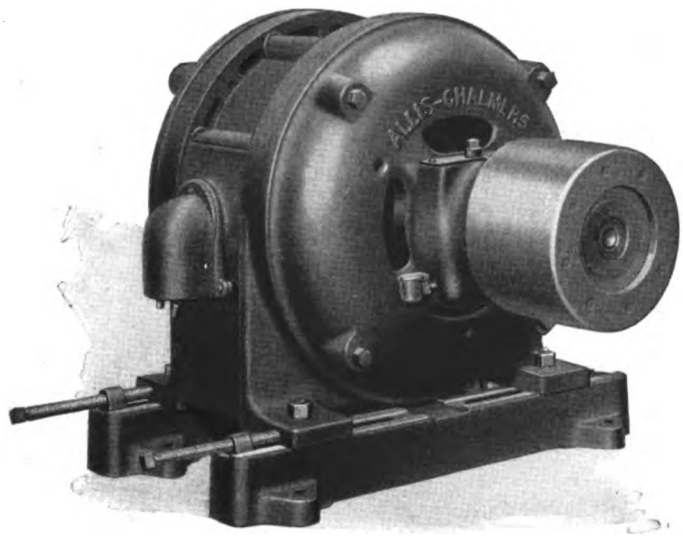
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The Original "Just Press a Button" System

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Polyphase Induction Motors

Constant and Variable Speed

60 and 25 Cycle

For All Standard Speeds

Send for Bulletin

Type "AR" and "ARY" Motors

Of new design throughout, taking full advantage of all improvements and advances made during recent years.

Designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.

Method of ventilation is very effective resulting in even cooling and avoiding of "hot spots."

Bearings are of liberal design with spacious oil-wells.

Insulation is of highest grade, stator being treated with baked-on insulating varnish making the whole structure dust and moisture proof.

Motors are for floor or ceiling mounting being provided with very stiff and substantial rails.

Conduit terminal boxes are regular equipment.

PRODUCTS:

Electrical Machinery
Gas Engines
Steam Engines
Steam Turbines
Condensers
Oil Engines
Hydraulic Turbines
Pumping Engines
Centrifugal Pumps
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Crushing Machinery
Cement Machinery
Flour Mill Machinery
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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, June, 1923 *Number 6*

How They Do It in California

And some reasons why everybody likes to talk about the things they do there.

THOSE WHO have never visited that state of flowers and golden sunsets in the empire west of the Rockies have a real treat coming. Californians like to talk about their state, its natural resources, its golden opportunities and particularly do electrical men like to refer to the fact that California leads all the states of the Union in kilowatt-hours used per capita. And well may they brag of the electrical development already there and certain to come in larger proportions.

Two years ago I had the pleasure of visiting by automobile the huge hydro-electric stations in the high Sierras and following the transmission lines they feed down into Fresno, the San Joaquin Valley, through Bakersfield and its oil well districts over the Tehachapi Pass into Los Angeles, the city whose count of 576,673 natives and non-residents is now of argumentative interest to the 506,676 people of San Francisco. All along this route are the unmistakable evidences of industrial and commercial development due to the harnessing of waterpower. But of particular interest is the extent and modernness of the electrical installations. In this section electrical energy is the recognized source of not only light and power, but heat as well.

The photograph shown here is one of several sent to me a little while ago by E. W. Weathers, proprietor of the Weathers Electric Motor Shop of San Diego, California. In a letter he said: "Believing that you might be interested in HOW WE DO IT IN CALIFORNIA when it comes to power wiring, we are sending you several pictures of some installations made during the past two years. Notice the main distribution system with its light, power and heat meters and the flexibility made possible by the trough connection for conduit instead of nipples. We are strong advocates of this trough connection."



You men from Maine southward to the Gulf and westward to the Rockies please take notice that Mr. Weathers says "We" all through his note and when he mentions California he puts everything in capital letters. This is the spirit of the empire west of the Rockies where everybody is a booster for what "We" — meaning the whole crowd, friends, enemies, just everybody—are doing to make that section what it ought to be and to let everybody know about it.

This kind of co-operative boosting is catching—if you don't believe it go to California and stay awhile. When you return your friends will know much more about the section and they will be certain that you have been there—you just can't help talking about it unless your prejudice is so deep-rooted that you can't see the power of the combination of self-interest and civic pride that is building the Pacific West by leaps and bounds.

But after all, in staid old New England and among the steel centers of the Middle West the same kind of electrical progress is going on. Somehow it is accepted as a natural course of events and those who are responsible for it have to be questioned long and earnestly to drag out the facts.

Now it seems to me that we can all learn a lesson from the Californians — not particularly Mr. Weathers, for he's fairly modest — but from all of them. Let's get that group-spirit of boosting everything that is good and correcting that which is bad.

Practical Pete

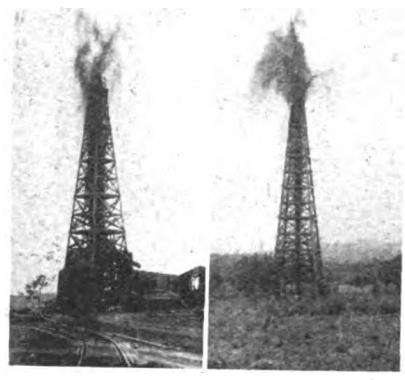
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A Glimpse Into the Works of the

Standard Oil Company

Which makes the crude petroleum of Mexico or Kansas usable and available to run automobiles or lubricate machinery. This is the sixth of a series devoted to the growth and extent of basic American industries.

PETROLEUM enters into our daily life under the guise of at least 250 different and marketable commodities. The crude oil of Mexico, Kansas, Texas, California, and of the old Pennsylvania oil fields must be taken to a refinery and transformed into a product to fit our needs. Crude petroleum in its original form can be used for but little more than fuel. Our needs demand naphtha for cleaning, gasoline for automobile engines, kerosene for fuel, paraffin, tar, asphaltum, and the numerous grades of lubricants from those suitable for sewing machines to the hard greases for big bearings, and a large number of other products. One of the big problems of the petroleum industry is that of transportation—from Mexico to the filling station where we get our "gas," or to the dealer who supplies our lubricants. Transportation charges alone, if the material were shipped this distance in small lots, would probably be more than is paid for the product in its finished state.



Gushers are the spectacular features among the oil wells, as the oil is under sufficient pressure to force it up in the air much higher than the derrick. These two gusher wells are located in Mexico.

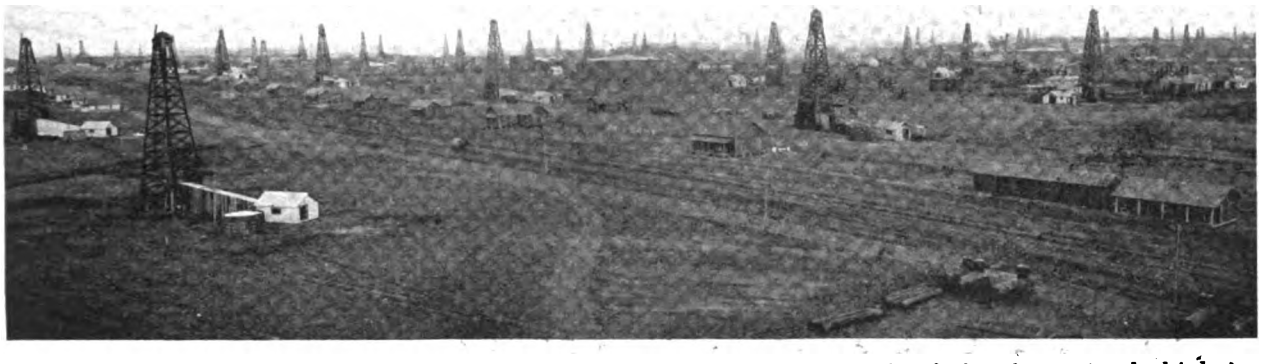
Another problem of the industry is that petroleum refines into definite products. However, there is a greater demand for some of these products than for others. For example, at one time the greatest demand was for kerosene, with an unusable surplus of gasoline. The advent of the automobile and of gasoline stoves changed this demand until now more gasoline is used than kerosene. By the discovery of a "cracking" process the heavier oils which remain after the gasoline is removed are broken down



This elevation view, which extends onto the opposite page, shows the extent of the Standard Oil Company's plant at Bayonne, N. J.

Oil is received here by pipe lines from the wells in the interior of the United States and from Mexico by tank ships. When refined, it is reshipped to all parts of the world. Here are shown the agitators for treating naphtha, gasoline and kerosene, the paraffin plants, stills and filters while near at hand are plants for coke, fuel oil, asphalt and tar. There is also a plant for making the sulphuric acid used in refining. Five hundred steel and 6,000 hardwood barrels are made daily, besides 100,000 5-gal. tin cans for exporting oil and 50,000 wooden boxes to carry them.

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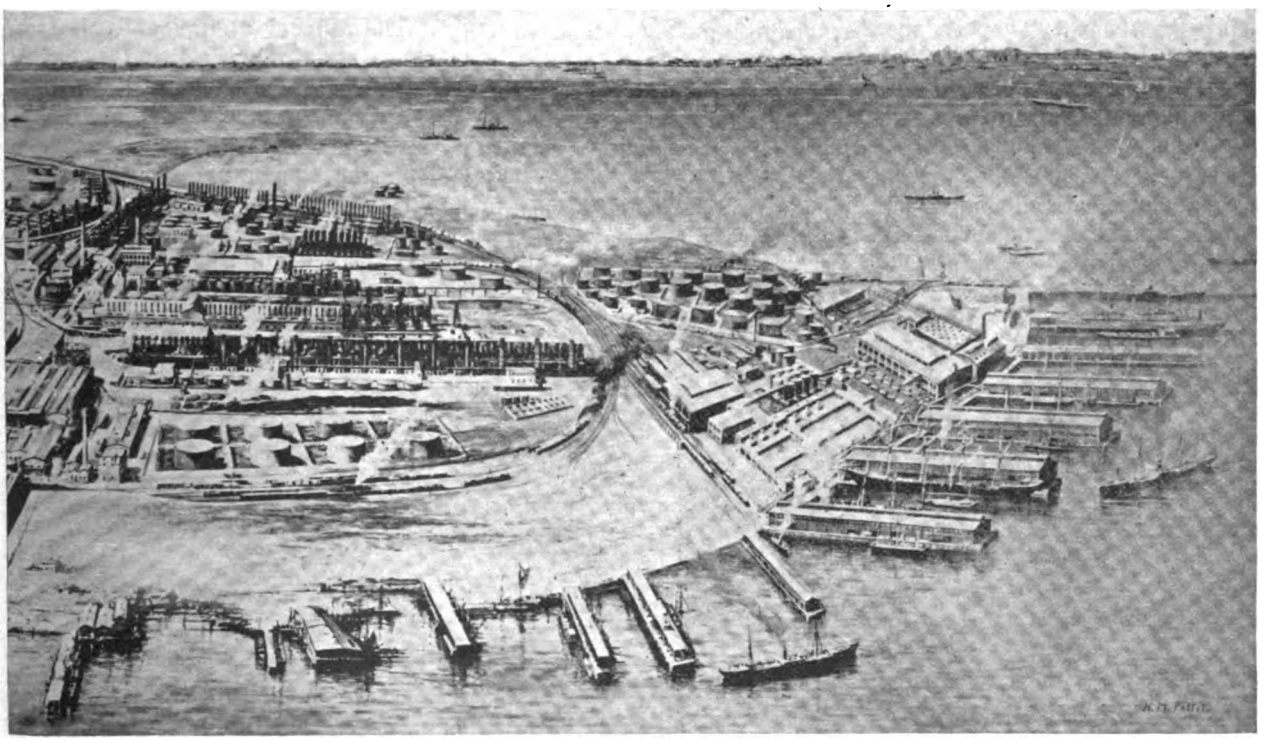
In contrast to the gushers shown on the opposite page, most oil wells must be pumped.

This shows the oil wells on a 160-acre oil lease in Kansas. Pipe lines extend from the Kansas oil fields to Whiting, Ind., at the southern end of Lake Michigan, through which the oil is pumped, thus making it unnecessary to ship the crude oil in tank cars. Booster pumping stations are distributed along the line at frequent intervals. It is estimated that 75,000 tank cars and 900 engines would be required continuously to handle the oil moved in the United States by pipe lines alone. This is one method of reducing transportation costs, as on an average a barrel of crude oil travels 1,000 miles to the refinery.

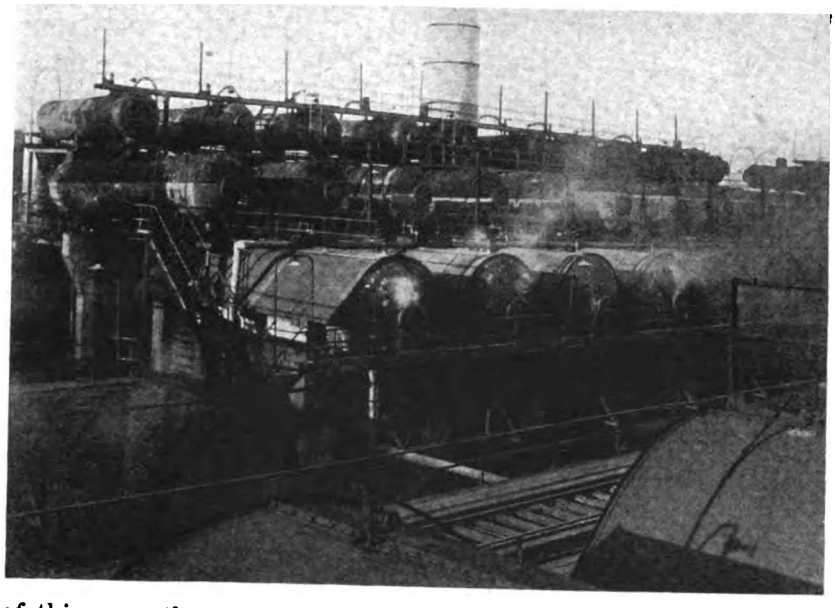
under heat and pressure into more volatile products, including gasoline, and in this way a larger amount of gasoline is made from petroleum. This and other special processes developed in the industry have helped maintain the balance of production against demand. These demands, however, have not been altogether natural, but have in many cases been created through educational programs and extensive advertising which have made "Vaseline," "Polarine" and "Nujol," among many other products, well known the world over.

Petroleum refining industries are listed as seventh in value of manufactured products in the 1919 census. In this industry the largest item of expense is cost of raw material, which is about three and one-half times the cost of manufacture. In the meat packing industry and also in the flour milling industry which have been discussed in this series this same condition exists but with a ratio of about seven to one. Although each of the three stands high in the rank of industries according to the total value of manufactured products, none of them stands very high in the number of wage earners employed. However, extremely large investments are required to carry on each of these businesses.

Until 1859 petroleum had been taken from shale, which gave a scant supply at a high price. It is interesting that attention is again being directed toward the recovery of petroleum products from shale. Edward L. Drake was convinced that he could get oil out of the ground by drilling a well and drove a shaft near Titusville, Pa., where he struck oil at a depth of 69 feet on Aug. 29, 1859. At the announcement



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A view of the double-drum pressure stills, for "cracking" the heavy ends of the oil under various degrees of steam pressure.

The largest demand of production is for gasoline. Under former methods of refining, only a definite amount of gasoline was obtained. In answer to the increased demand, processes were invented which "cracked" a part of the heavier oils into the lighter, more volatile gasoline. Obviously, fire is one of the biggest hazards of this industry.

of this news there was a rush to the oil field similar to the stampede for California gold ten years before. The demand for kerosene was so great that it sold for $1 a gallon. The methods of distilling and distributing were, however, crude and wasteful. Little refineries were set up near the wells. Thousands of gallons of gasoline were thrown away because it had no use. It is astonishing to learn that as late as 1897 there were 6,000,000 gallons of gasoline in Bayonne, N. J., which could easily have been bought for 5 cents a gallon. In about 1900 when the automobile began to come into general use the consumption of gasoline outstripped kerosene. In 1919 about 3,426,000,000 gallons of gasoline, 1,397,000,000 of kerosene, 6,290,000,000 gallons of fuel and gas oil and 568,000,000 gallons of lubricants were sold in the United States. In addition to this large quantities were exported.

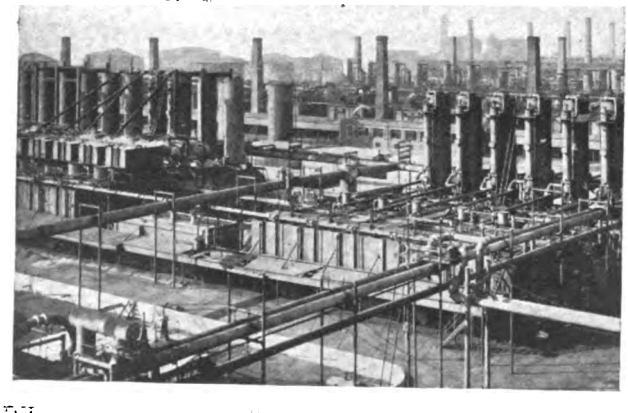
In the early '60's, when all operations connected with oil production were still imperfect, John D. Rockefeller, then a youth of twenty-one years, with two partners went into the oil business in Cleveland, Ohio. Their partnership prospered and near the close of this decade the Standard Oil Company was formed as a development of the partnership. The company then invited others to combine with it and in 1870 the Standard Oil Company of Ohio was organized with a million dollars capital. The Standard Oil Trust was organized in 1882, but was dissolved by the Supreme Court into thirty-four companies in 1911.

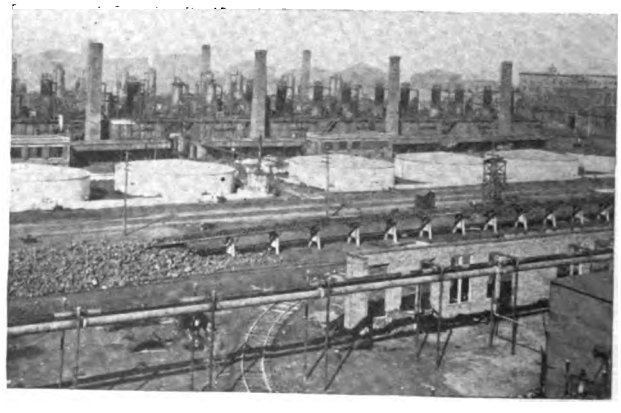
Crude petroleum yields four main products: (1) gasoline, naphtha and benzine; (2) kerosene; (3) lubricants, and (4) fuel oil. The innumerable by-products include vaseline, paraffin, road oil, asphalt, and petroleum coke. These are distilled out one after the other and each must be refined before it is usable. Care must be exercised in distilling that temperature and pressure do not get too high. Fire is one of the big hazards.

The main processes required are: (1) Getting the petroleum from the ground; (2) carrying it to the refineries; (3) refining it, and (4) distributing the products to the user. The first pipe line was laid in 1865. By 1911 the Standard Oil Company had 10,000 miles of trunk pipe lines and 80,000 miles of branches.

The refinery at Bayonne, N. J., shows strikingly the size, the multiplicity of operations and the diversity of products of the Standard Oil Company. Six thousand men and women are employed at this plant. In addition many thousands are employed in obtaining the wide distribution of the products of petroleum.

A general view of the first battery of crude, steam stills are shown in the foreground. The illustration at the right shows the rear of the third and fourth batteries of crude stills with the coke trestle in the foreground. The main storage tank field may be seen in the distant background.





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Some Ways in Which

Shutdowns Have Been Prevented

During a Period of Nine Years by the Strict Application of a Common-Sense Maintenance Plan

By E. S. LINCOLN
Consulting Industrial Engineer, Portland, Me.

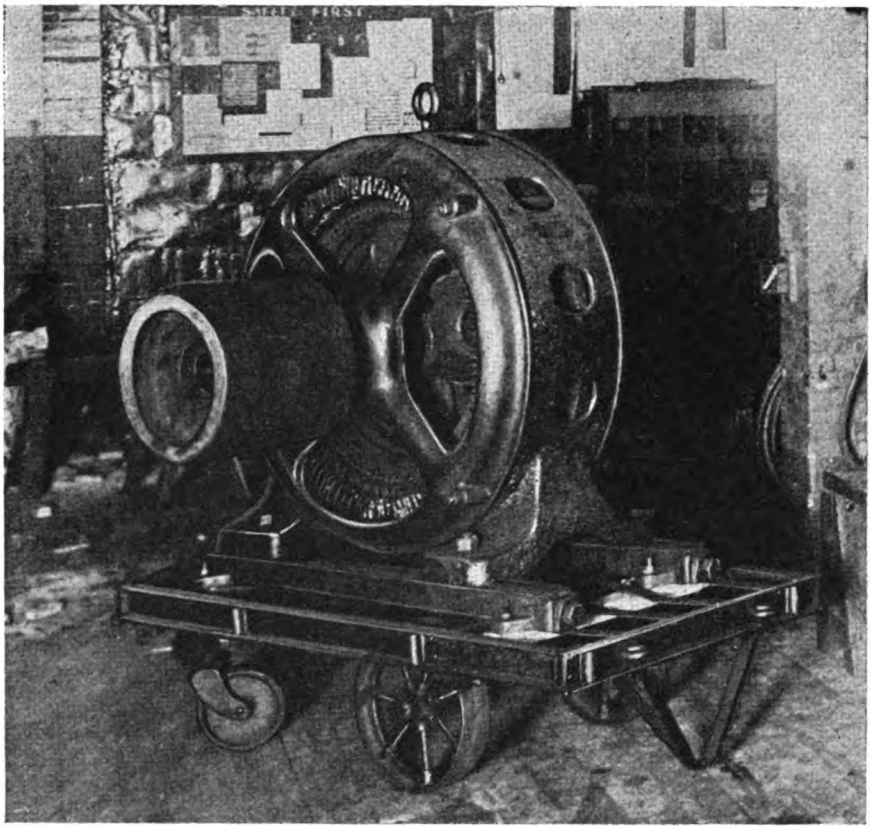


Fig. 1—This motor is kept on its small truck ready to be moved in a hurry.
Three large motors are equipped in this way to replace motors which break down or show signs of serious trouble.

A METAL-STAMPING plant does not offer electrical equipment a peaceful life. The variable loads, the high temperatures, the fumes and grit create troubles of various sorts. However, proper attention to installation and maintenance procedure will prevent most of these troubles as it has done for the Bossert Corporation at Utica, N. Y. In this plant no serious interruptions have been experienced for a period of nine years. Several burnouts have occurred where motors were purposely overloaded in order to increase production temporarily, but this has happened only a few times.

The secret of this freedom from trouble is frequent and thorough inspection and the fact that repairs are made at once and the plant always kept in good operating condition. Another reason is that the original installation was scientifically designed, and the construction work was carefully carried out by experienced electrical men.

Electrical energy is used in this plant for general power purposes, for electric welding, and for lighting, electroplating and miscellaneous uses such as operating cranes, industrial trucks, electric tools, and so on. The loads are variable especially when the large presses are in use and only a small portion of the load is in any way steady, with the result that the power factor is very low and variable. Furthermore, the continual expansion of the business requires a large amount of installation work. Changes in production from one article to another require considerable temporary work which is hard for an electrical department to take care of along with its regular duties.

Some Bad Operating Practices That Have Been Stopped

A comparison between the company's original electrical system and that in use today will give an idea as to what proper installation and a competent electrical department have done to assist in improving the plant production. Ten years ago this corporation had in use about sixteen motors ranging from 1 hp. to 100 hp. and a very small amount of other electrical equipment. No regular electrician was employed and the company did not have a plan for maintenance or inspection. At that time the electrical system was not entirely satisfactory, which is true of most systems that do not have proper supervision. The original system was rated at 220 volts, two-phase, sixty cycles. Considerable difficulty was experienced in starting the motors after the noon hour, due to the fact that no systematic method of starting was in effect and as soon as the whistle blew the operators would attempt to start all motors at once, with the result that all of the circuit breakers would open. To avoid this difficulty all circuit breakers were "blocked," leaving many of the motors without electrical protection.

The fuses and cutouts were located in various parts of the plant, some

CLEANING A MOTOR which has its windings caked with oil and dust is an everyday maintenance job in many plants. In a metal-stamping works there are many other problems equal in importance and these are dealt with in this article. By following a simple system of maintenance procedure the Bossert Corporation at Utica, N. Y., has experienced no serious shutdown in nine years. The details are applicable in other plants and will help in bringing about similar results.

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on ceilings, some on posts, but only a few in the cabinets where they belonged. Whenever a fuse burned out it was very difficult to locate the cutout, and often it required half an hour to make a replacement. As various types of fuses were in use the particular type to fit the cutout had to be found. The company did not possess indicating meters; so tests were never made. Owing to the small amount of copper used in conductors the electrical loss was considerable and none of the motors ever received rated voltage. In some cases the drop in voltage between the transformers and the motors was over 30 per cent. Since this first system was in operation many changes have taken place and at the present time the company has one of the best installations in the country and has organized a very efficient electrical department.

Table I—Starting Torque of Squirrel-Cage Motors

The starting torque with rated voltage applied at the instant of starting from rest should not be less than the following values. Where the voltage is lower, the torque will be reduced as the square of the voltage. This table is one of the standards formulated by the Electric Power Club.

Synchronous Speed		No. Poles	Per Cent of Full-load Torque
25 Cycles	60 Cycles		
1500	3600	2	150
750	1800	4	150
500	1200	6	135
375	900	8	125
300	720	10	120
250	600	12	115
214	514	14	110

Present Electrical System Has Many Good Features

At the present time, the company has in use 140 motors rated from 1/12 hp. to 100 hp., the total connected motor load being 1,100 hp. The voltage was changed from 220 to 440 volts. The present substation, which is centrally located in the plant, contains two 600-kva. transformers for the power service. The lighting service is supplied by two 100-kva. transformers, and the electric welding load is taken care of by four 200-kva., single-phase transformers. Energy is received from the Utica Gas & Electric Company on a four-wire, three-phase system over a special line from their local substation. The maximum demand on the plant is about 575 kw. and the monthly consumption of power is in the neighborhood of 185,000 kw.-hr. The reason for the large power transformer capacity, in reference to the maximum demand, is due to the low power factor of the power load. This load is at its maximum when the welding load is at its minimum. The reverse of this is true on account of the change of the manufacturing processes. Owing to the variable load conditions of the plant the power factor runs from 60 to 70 per cent. This power factor would be much lower if it were not for the operation of a 750-kva. synchronous condenser.

All circuits are protected by circuit breakers on the substation switchboard. These protect the mains and each motor is protected locally by its own fuses which are placed in the circuit before the compensators.

Motors in Plant Are Started One at a Time

All wiring of every nature is placed in iron conduit and carefully protected. The motors are of the squirrel-cage type and no slip-ring or synchronous motors are in use. In order to avoid excessive power requirements in starting, the machine foremen start the motors one at a time, beginning about five minutes before the plant is put in operation at morning and noon.

In order to avoid electrical accidents the entire installation has

Table II—Principal Items Carried in Maintenance Stock

THIS PARTIAL LIST shows some of the main items stocked by the Bossert Corporation in its metal-stamping plant, having 140 two-phase, 440-volt motors ranging in size from 1/12 hp. to 100 hp. and aggregating 1,100 hp.

I—Motors and Motor Repair Parts

100 hp., 75 hp., 50 hp., 35 hp., 15 hp., 7½ hp., 5 hp..... 2 each
25 hp. ..... 1 each
20 hp., 10 hp..... 3 each
From 3 hp. to ½ hp.....10 total
Total number equals 31 motors aggregating 705 hp.
Bearings—For all large motors one extra set for each; for smaller motors where bearings are interchangeable, less than one set per motor.
Coils—A few are stocked.
Brushes—One set for each direct-current machine.

II—Motor Starting Devices

Compensators, ranging from 7½ hp. to 100 hp. 8
Oil switches and pushbutton starters for motors of 5 hp. and under, several are stocked.

III—Fuses

Economy refillable, 600 volt, sizes up to 100 amp.—
Number of spares.....10 each
Above 100 amp..... 5 each
Extra links, all sizes.....25 each

IV—Lamps

40-, 60- and 100-watt sizes.....5 cases each
Two cases of each of the above sizes are kept marked with the company's name.
200- and 300-watt sizes.....3 cases each
500-watt size for flood lights.....1 case

V—Wire

Rubber-covered—
No. 14 single and duplex.....2000 ft. each
Nos. 12 and 10.....1000 ft. each
Nos. 8, 6, 4, 1, 0, 00.....1000 ft. each
No. 0000 .....2000 ft.
Super-Service Cord (Rome Wire Co.)
No. 16 duplex.....1000 ft.

VI—Conduit

½ in., ¾ in., 1 in. and 1¼ in.....20 lengths each
1½ in., 2 in. and 2½ in.....10 lengths each

VII—Storage Batteries

For 20 industrial truck batteries and for smaller batteries used on railroad alarm, auto-call and crossing-signal devices, spare parts are kept, including jars, separators, plates, terminal posts, connectors, and so on.

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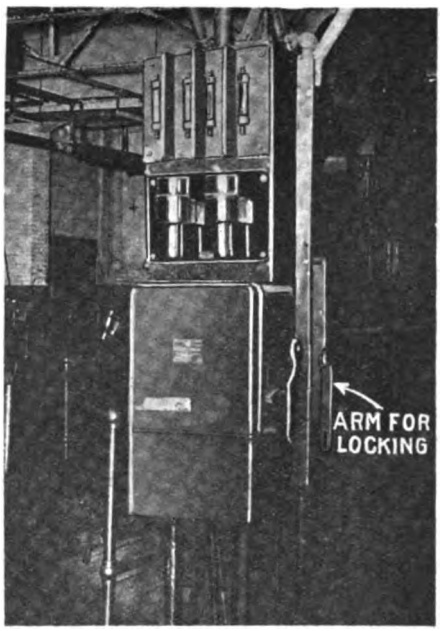


Fig. 2—This compensator handle can be locked in the open position.

The handle is passed through the slot in the arm seen hanging from the post. A padlock is then locked on the handle through a hole drilled in it. Several departments have their own locks which cannot be opened by any other department.

been made with no exposed live parts and all lighting panels are of the safety type. This, of course, is the best precaution, as the operator cannot come in contact with live circuits.

Compensators Can Be Locked Open for Motor Repairs

In order to make it impossible to start large presses or other machinery when repairs are being made, all compensators are arranged so that they can be locked with special padlocks as shown in Fig. 2. These special locks are in the care of the electrical, millwright, and production departments. These locks are all separate, and the keys of one department cannot open the lock of another. This system avoids the danger of misunderstanding between the various workmen in the three departments.

The headquarters for the electrical department are near the center of the plant, and only a short distance from the substation mentioned above. A room 70 ft. x 50 ft. is devoted entirely to this department. The room contains a few machine tools, shown in Fig. 3. It is also used for charging the storage batteries of the industrial trucks, as shown in Fig. 6. The panels directly in back of the batteries are used for charging purposes. A rope tackle, shown at the right, is used for handling these batteries. The room is well ventilated, so that the acid fumes are not noticeable. In the background of the picture can be seen two 20-kw. motor-generator sets, which are used to supply 220-volt direct-current service to the traveling cranes and electro-magnets in the receiving and storage shed.

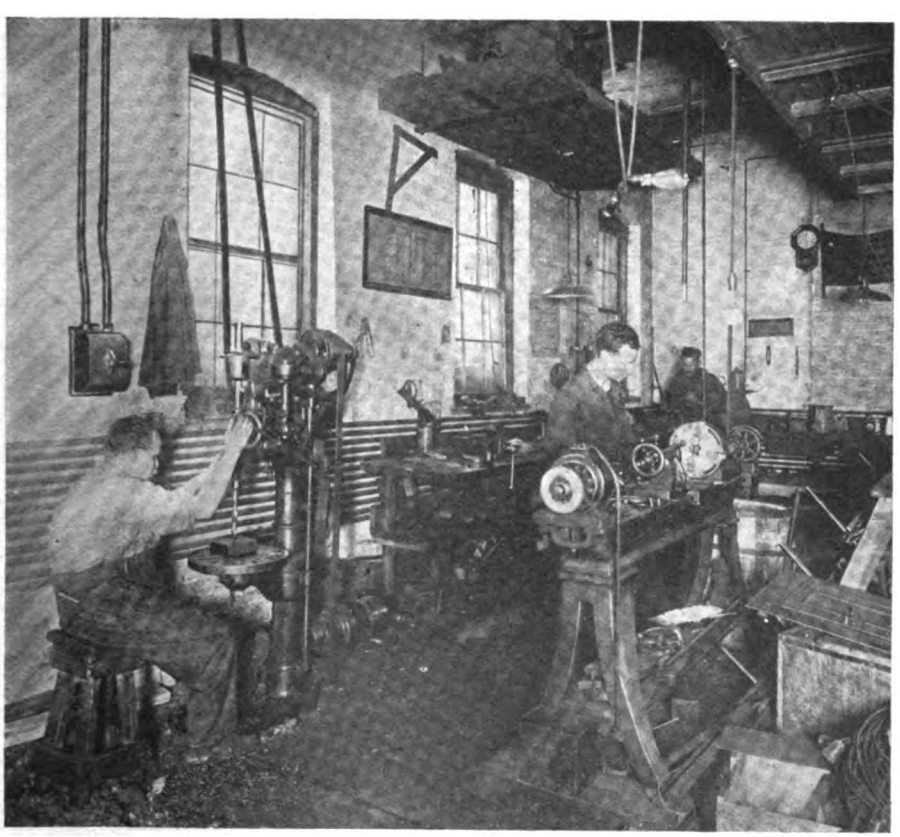


Fig. 3—Repairs are made in this room.

Four small motor-generator sets are used for charging storage batteries and are located in this same room.

In addition to this equipment there are two 2,400-amp. motor-generator sets located in the electroplating department. A 2-kw., 110-volt direct-current motor-generator set is also used in the tool room for operating the magnetic chucks. A similar 3-kw. set is used in operating the tabulating machine in the cost department. A dozen single-phase motors of 1 hp. to 3 hp. rating are used in various parts of the plant for different purposes.

In addition to the power and welding service the electrical department also has charge of the fire-alarm and auto-call systems used in the plant.

How the Maintenance Department Is Organized

The electrical department has been for nine years and still is in charge of H. R. Hall, who has seven men to assist him in his work. An organization chart is shown in Fig. 4. The duties of these men are as follows: Mr. Hall acts as superintendent and takes charge of all installation, maintenance, inspection, and repair work. One assistant is kept in the shop at all times for miscellaneous repairs and battery charging. Two men devote their entire time to the maintenance and inspection of the electric welding equipment, which is a very essential part of the business. The other four men devote their time to making the necessary repairs around the plant, inspections, and whatever new installation work is required. Other duties which come under the electrical department are repairs on the portable electric tools, call systems, and so forth, which are used throughout the plant. All of the necessary supplies are kept in the electrical department and are given out when proper requisitions are received.

This company does not employ an elaborate system for maintenance work, but has a common-sense plan of taking care of all equipment, and this plan produces results.

The regular routine consists of going over all motors and motor-generator sets at least once every two weeks. This consists of cleaning the motors, renewing the oil in the bearings, testing the air gaps and making a general inspection.

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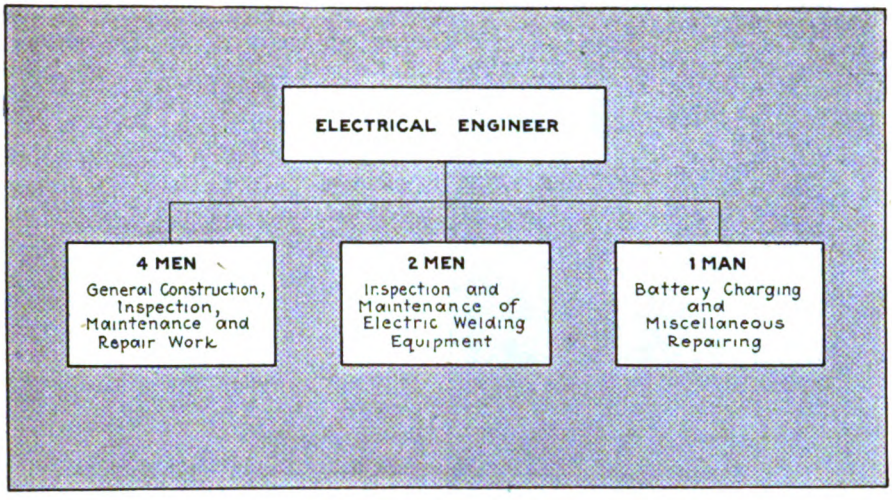


Fig. 4—Maintenance organization for metal-stamping plant having 1,100 hp. in motors.

These men take care of all electrical equipment, including motors, of which there are 140 ranging from 1/12 hp. to 100 hp., welding machines, eight industrial trucks, signal systems, lights, and other equipment.

The old oil that comes out of the motors is used in the plant for other purposes than lubrication, so that none is wasted. All bearings are thoroughly washed with kerosene before putting in the new oil. The motors are blown out at this time with compressed air at 45 lb. pressure, taken from the regular air system of the plant.

Cleaning Windings Covered with Oil and Iron Oxide

Owing to the large amount of oil vapor and iron oxide in some of the rooms, due to the operation of the presses, it is necessary to use gasoline in the form of a spray for cleaning the motors.

The suction of the motor draws in the dirty air and the oil and dirt settle on the coils. As the coils are warm the oil sets in a thin film. It is impossible in many places to secure fresh air from the outside in order to avoid this trouble. Numerous methods have been tried for removing the film but the gasoline spray has been found to be the most satisfactory. The rotor and end bells are removed from the motor and the stator is allowed to cool. Then by means of a nozzle and 30-lb. air pressure the gasoline is sprayed on the coils. This blows off the thin film of oil and dirt. Sufficient time is then allowed for the remaining gasoline to evaporate, after which the coils and the rotor are painted with quick-drying japan.

The lighting system, alarms and other electrical equipment receive regular inspections varying from once in two weeks to monthly. Eight industrial trucks are in use and these, including the batteries, are given careful inspection once a week, and are thoroughly overhauled yearly.

Graphic load charts are frequently taken, especially when any changes are made in the power requirements of a particular motor. Continuous voltage charts are taken on the main bus. All charts are filed away for future reference.

Records are kept in the substation showing the power factor, maximum demand, primary current and kilowatt-hours consumed. Electrical energy for each department is measured by a recording watt-hour meter for the use of the cost department. All substation charts are kept on file by the central station.

When trouble is experienced anywhere in the plant it is immediately reported to the electrical department, which in turn gets right after the difficulty and makes the necessary repairs. In case of a burnout or any serious difficulty which would make it necessary to remove a motor, the foreman of the department notifies not only the electrical superintendent, but also the "rigger" and "millwright" in order that no time will be lost in making the change. The employees of the electrical department are available at any time and can be reached on short notice by telephone or by the auto-call system.

Repaired Motors Are Given Brake and Ground Tests

In order to save time when one of the large motors breaks down, three of these are kept mounted on small trucks ready for taking immediately to the job in case of a breakdown. Two 100-hp. and one 75-hp. motor are always kept mounted on these

Fig. 5—Motor-record card and repair-material sheet.

On the repair material sheet are charged the repair parts and materials used on the motor. Each sheet represents one repair job. A copy of the sheet is filed with the motor record card while another copy goes to the accounting department.

ELECTRIC MOTOR RECORD

DATE 19

HORSE POWER 75	TYPE OF MOTOR I-9-10-75-720	MOTOR NO. 21
MANUFACTURER General Electric Co.		MANUFACTURER'S NO. 1051704
USED IN DEPARTMENT Press AT Dio #5		TO DRIVE MACH. NO 86

R. P. M. OF SHAFTS		SIZE OF SHAFTS		PULLEY DIMENSIONS		BELTS			
MOTOR	DRIVEN	MOTOR DIA. X LONG	DRIVEN DIA. X LONG	MOTOR DIA. X WIDTH	DRIVEN DIA. X WIDTH		LENGTH	WIDTH	PLY
720	252	3 7/16"	3"	14" 15"	40" 15"	MOTOR	46'	14	3
						DRIVEN	34'	14	3

G.E. Compensator #1587625 CR1034 Relay Panel #189783
From #3P1 Type 1792 Ruhe Block-150 Amps.

DATE	ORDER NO.	EMP. NO.	HOURS	OPERATION
2/10/23	65	87	1½	Repairing

Form 259 2-23 5M

INDIRECT MATERIAL USED Date 2/10 192 3

Quantity	DESCRIPTION	Price	Amount
8	Part Pa. G.E. Cat #129566		
4	" Qa " " #129568		
1	" Oa " " #129565		
5	Gal. Compensator Oil		

(Over)

For what Purpose Used Repairing Compensator

Order No. #65

Charge to Dio. #5

Dept. No. #61

Acct. No.

Deliver to Dept. No. #61 Man No. 87

Credit

Store Room No.

Acct. No.

Signed H.R. Hall

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trucks. One of these is shown in Fig. 1.

After the windings of a motor have been repaired it is given a ground test and a brake test. For the ground test 600-volt direct current is used. One side of the 600-volt line is connected to the winding and a 600-volt voltmeter is connected to the frame and the other side of the line. If the meter shows over 4 volts, the winding is grounded. If the ground is slight it may be removed by drying out. If the reading is very low then the 150-volt scale of the meter is used. A reading of over 15 volts on this scale indicates that the motor should be dried out. The 600-volt winding of this meter has about 60,000 ohms resistance, while that of the 150-volt winding has 15,000 ohms resistance.

If the motor winding is not grounded then a brake test is made. The brake consists of a steel friction block lined with brake lining and kept cool by water. The torque is measured at the same time that ammeter readings are taken of the motor current.

The torque is measured by means of a lever arm fastened to the friction block. The outer end of the arm rests on a spring scale. The horsepower is calculated from the formula: Hp.=(weight in lb.)×(length of arm in ft.)×(r.p.m.)÷5252.

If the current drawn is greater than the full-load current when the motor is delivering its rated horsepower, the motor is not in good condition. The trouble may be improper connections, loose rotor bars, poor bearings, lack of lubrication, and the like. After new bearings are put in a motor it is allowed to run idle until the bearings are cut in.

Compensators which have been repaired are given a ground test similar to the one described for motors. They are then tested for starting torque and current. A motor of the proper size is connected to the compensator and the brake is applied to the motor. This test is made on various taps of the compensator to determine which should be used for the service. The proper starting torques of various motors as specified by the Electric Power Club are shown in Table I. This table shows the torque when rated voltage is applied. When a lower voltage is applied from a compensator the torque is reduced as the square of the voltage. For instance, if the 70 per cent tap is used the torque will be 0.70×0.70=0.49, or 49 per cent of that shown in Table I. The current should not be over about 250 or 300 per cent of full-load current.

A record book which is kept in the office of the department contains information covering all repairs made, dates of inspection and other records and acts as a ready reference for obtaining data for the department. The results of all the work of the department are recorded in this book under their proper headings. This book becomes an important factor in the operation of the department and contains information of much value. The superintendent is able to look up any data covering inspections or trouble with the electrical equipment, and experience has taught the department the necessity of writing out in detail its activities.

Each motor has a record card like that shown in Fig. 5. This card contains data on the location of the motor, and also information on the compensator, pulley, bearings, and the like. In Fig. 5 is also shown the material sheet used when making repairs. On this sheet are put down the materials to be used on a repair job. The original sheet then serves as a requisition on the stock room. One copy of the sheet is filed with the motor record card. After the stock room has issued the material the sheet is sent to the accounting division. *(Continued on page 324)*

Table III—Portable Meters Used in a Large Metal-Stamping Plant

Alternating-Current Meters	Direct-Current Meters
1 Two-phase graphic wattmeter	1 Graphic wattmeter
1 Graphic ammeter	1 Graphic ammeter
1 Two-phase indicating wattmeter	1 50-amp. ammeter
1 150-amp. ammeter*	1 500-amp. ammeter
1 300-amp. ammeter*	1 300-volt voltmeter
1 30-volt voltmeter	1 750-volt voltmeter
1 120-volt voltmeter	
1 300-volt voltmeter**	

*A cable-testing current-transformer set accompanies these meters.

**A multiplier is used with this meter to measure voltages of 600 volts, 900 volts and 1800 volts.

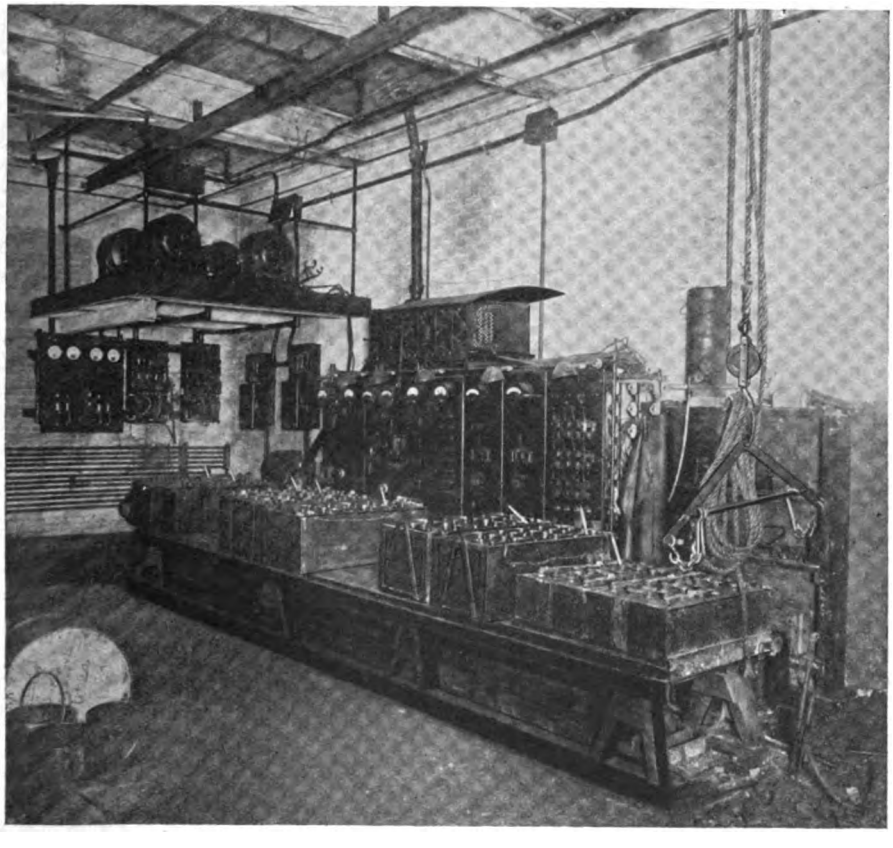
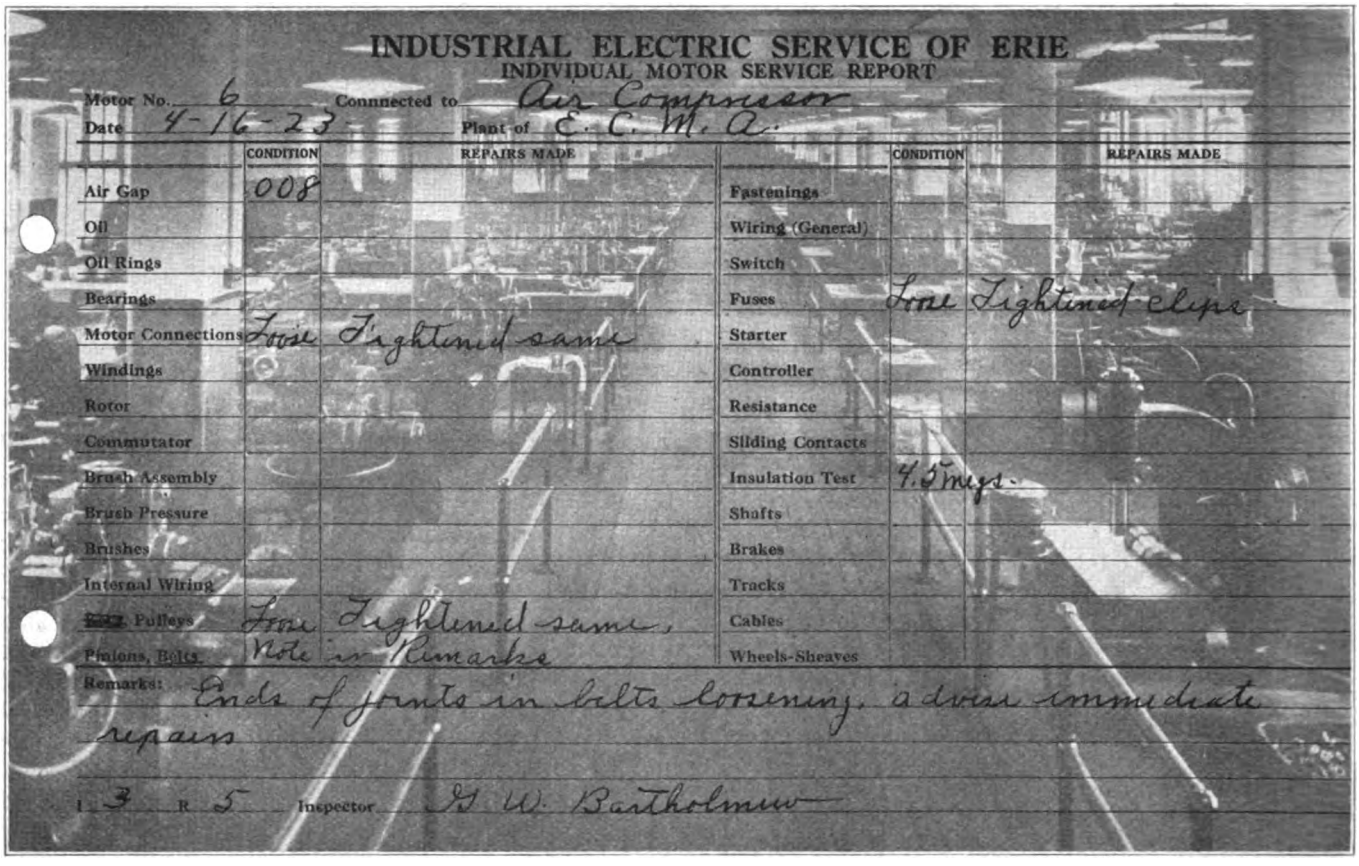


Fig. 6—Where the batteries are charged.

This is another side of the room shown in Fig. 3. Note the stands made for holding the batteries and the runway overhead for moving the batteries after they are lifted by the rope tackle.

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INDUSTRIAL ELECTRIC SERVICE OF ERIE
INDIVIDUAL MOTOR SERVICE REPORT

Motor No. 6 Connected to Air Compressor
Date 4-16-23 Plant of E. C. M. A.

	CONDITION	REPAIRS MADE		CONDITION	REPAIRS MADE
Air Gap	.008		Fastenings		
Oil			Wiring (General)		
Oil Rings			Switch		
Bearings			Fuses	Some	Tightened clips
Motor Connections	Loose	Tightened same	Starter		
Windings			Controller		
Rotor			Resistance		
Commutator			Sliding Contacts		
Brush Assembly			Insulation Test	4.5 Megs.	
Brush Pressure			Shafts		
Brushes			Brakes		
Internal Wiring			Tracks		
Pulleys	Some	Tightened same	Cables		
Pinions, Belts	Note in Remarks		Wheels-Sheaves		

Remarks: Ends of joints in belts loosening, advise immediate repairs

I 3 R 5 Inspector G. W. Bartholmew

The inspector makes out a report like this covering all apparatus inspected. This is known as report form No. 1 and is filed in a loose leaf binder for use in making up report form No. 2 shown on page 292. This sheet measures 6 in. by 9.5 in.

How to Figure Rates for

Industrial Maintenance Service

With an Outline of What this Service Includes and How it Has Been Handled

By G. W. BARTHOLMEW

Manager, Industrial Electric Service of Erie, Erie, Pa.

IN THE April issue of INDUSTRIAL ENGINEER, page 211, the writer answered an inquiry regarding a plan for contracting to render a maintenance service to industrial plants on a monthly basis. Owing to the inquiries which have since been received from readers of INDUSTRIAL ENGINEER regarding further details of figuring out rates for this service the writer has compiled a description of the method which he has developed in conducting such a maintenance service during the past two years.

Briefly, the fees are based on the work called for by an individual motor and vary with the size, type, accessibility and character of control used. An aggregate of all motor fees constitute the monthly fee. Discounts are arranged for installations of over ten motors with additional charges for installations of less than ten motors. A base rate has been worked up to take care of a semi-monthly service with additions for a weekly service and deductions for monthly periods with a minimum rate for small installations.

IN THIS ARTICLE Mr. Bartholmew outlines details of a maintenance service for small industrial plants. These details are based upon two years of experience in developing this work and embody plans which have resulted in savings to customers and a fair profit for the service rendered. Such a service is badly needed in many cities and electrical repair shops can handle it without much additional expenditure.

The popularity of this service may be judged from the fact that the only cancellations of the service agreements made have been due to retrenchment on the part of industrial plants.

In large industrial plants an electrical maintenance force is a necessity and economy when sufficient equipment is operated to keep this force busy. In the smaller plants, however, where maintenance and repair work is not sufficient to keep one or two experienced maintenance men busy all the time and they are put on odd jobs in their spare time, then the maintenance force is un-economical when a repair service can be contracted for by an outside organization. This is due to the fact that when maintenance men are not busy all the time they will take considerably more than the necessary time in

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completing maintenance jobs. Moreover, the odd jobs which are assigned to them to do could be performed by a less expensive man in a satisfactory manner.

Previous to the time the writer established his maintenance service while working as an estimator on power construction, he observed that in many cases when an outside repairman was called in on a repair job that he attended only to the defects that he was called upon to handle. He left untouched defects in other equipment which, if properly cared for at the time, would have prevented shut-downs and consequent expensive repairs. It was evident to him then that if it were possible for small industrial plants to employ the services of a competent repair man on a part-time basis many troubles could be anticipated before they became serious and a material saving in operation and production made possible. He then set about to devise a method for doing this work that would prove mutually remunerative to himself as well as his customers through the savings that would result.

The first question faced in organizing this service was the matter of rates. At the start an arbitrary schedule of rates was developed. This was based on my experience as an electrical repair man in several large industries in the central west covering a period of several years. During the past two years since this service has been in operation more definite schedules have been developed and are shown in Tables I, II, III, and IV. The service which is provided has been divided into four classes which are described as plans Nos. 1, 2, 3 and 4 in the form of service agreement which is now used, as shown on this page.

Plan No. 1 provides for a thorough inspection at regular intervals and the rendering of a written report giving details of the results of this inspection together with recommendations for changes or repairs and adjustments necessary to insure safe and economical operation.

Plan No. 2 includes plan No. 1 together with a written report on same and in addition oiling, wiping and repairs of a minor nature, such as brush seating, correcting brush tension and surface defects in the commutator, sanding rough commu-

This Service Agreement Outlines the Work to Be Done Under Plans Nos. 1, 2, 3 and 4.

INDUSTRIAL ELECTRIC SERVICE OF ERIE

SERVICE AGREEMENT

We the INDUSTRIAL ELECTRIC SERVICE OF ERIE agree to furnish services of Plans Nos. _____ as outlined in description of plans as shown in this agreement, on electrical equipment consisting of _____ motors and starting equipment of same, located at _____ property of _____ for the sum of _____ per _____ payable _____

Plan No. 1, thorough inspection of listed equipment at intervals of _____, furnishing written report of same and recommending any changes necessary to safe and economical operation of same.

Plan No. 2 includes Plan No. 1 and minor repairs and adjustments not covered in Plan No. 4 at intervals of _____

Plan No. 3. Oiling services at intervals of _____

Plan No. 4 for replacements of parts, repairs to parts where necessary to partially or completely dismantle, rewiring partially or completely, or to make new installations, a rate of _____ per man per hour for the first five (5) hours and a rate of _____ per man per hour for each hour over five (5) hours, will be furnished men to competent electrical workers.

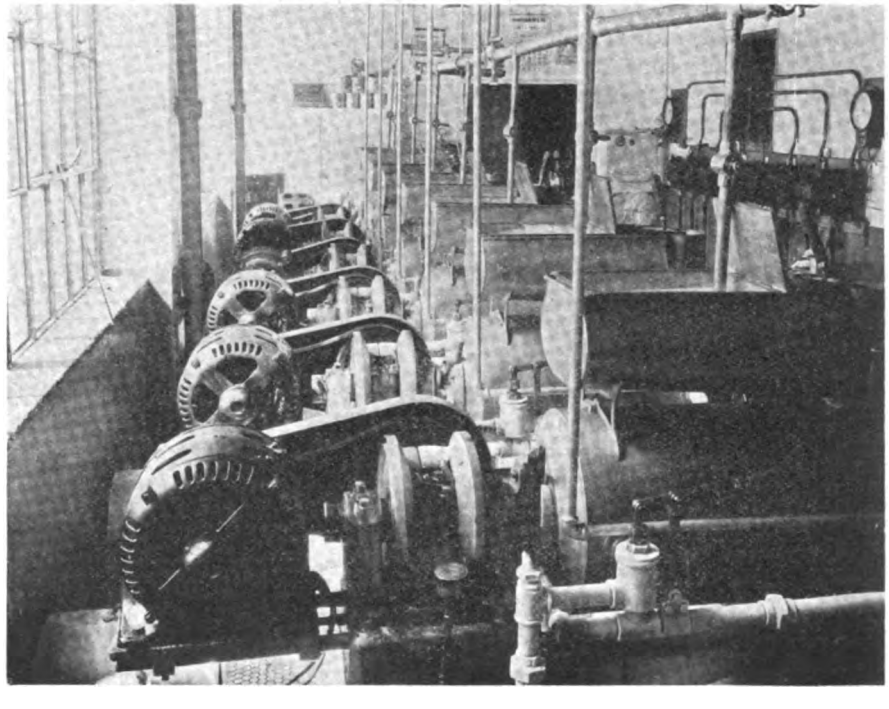
Trouble calls to the amount of _____ hours will be allowed between inspections without charge. The maximum number of trouble calls without charge allowable under this agreement shall not exceed _____ per _____. All additional trouble calls will be charged at the rate of _____ per hour, per man.

Owner to furnish any necessary materials.

Date _____ Signed _____

Expires _____ INDUSTRIAL ELECTRIC SERVICE OF ERIE

By _____



This group of freezers in an ice cream factory shows ideal conditions for thorough inspection.

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An Example Showing How the Schedule of Rates Is Applied to a 27-Motor Job

Motor No.	Size	Motor Rate	Total	Starter Rate	Total	Whole Rate
7	Fract.	$0.55	$3.85	$0.00	$0.00	$ 3.85
8	1 to 3	.65	5.20	.06	.48	5.68
5	3 to 5	.80	4.00	.08	.40	4.40
6	5	1.00	6.00	.10	.60	6.60
1	7½	1.15	1.15	.11	.11	1.26
					Total	$21.79

tators, tightening loose connections in leads and many other small defects that take but a short time to correct.

Plan No. 3 covers an oiling service only, of all electrical equipment at frequent intervals. No repairs are covered in this plan.

Plan No. 4—Where extensive repairs are required and construction work needed it is agreed to furnish a competent man on a sliding rate of charge determined by the length of time necessary to complete the work. To regular customers it has been found advisable to discontinue the sliding rate and charge for the work on a flat-rate basis, owing to the fact that I employ only competent and experienced men. Another point that interests our regular customers is that I call on them for help when they are in a position to furnish it.

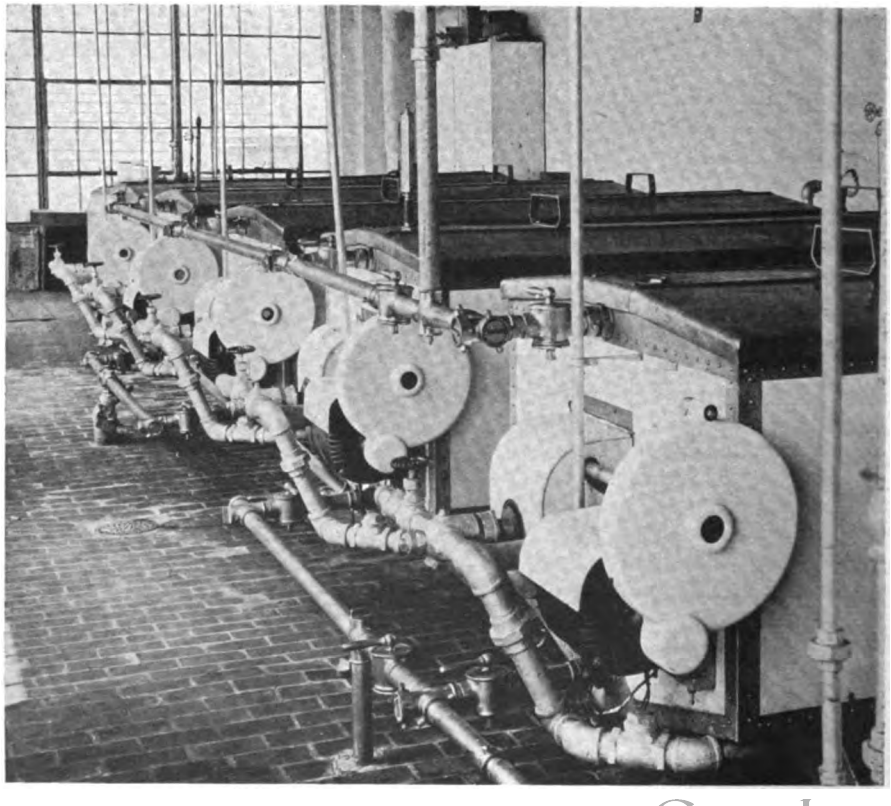
To encourage the contracting of maintenance service on a regular and continuous basis, all construction and repair work for other than regular customers is billed out at a rate 20 per cent in excess of the labor rates furnished with a maintenance contract. The time allowed for trouble calls is 10 per cent of the rate of 75 cents per hour for the period between regular inspections. All time over the allowable time for regular inspections is billed as an extra charge.

For example, a rate of $6.00 per period (period is the interval between inspections) is assumed. Trouble calls to the amount of 60 cents, which is usually figured as one hour if the charge is less than $1.00, are allowed. All time over one hour is charged for at regular rates, say $1.50 per hour. Then if two and a half hours are consumed in making a repair, we charge one and a half hours, or $2.25 in addition to our rate for the period which makes a total of $8.25 for the period.

Although it is not stipulated in the service agreement, it has been our custom when the trouble is the result of neglect on the part of the inspector to do the work without a charge. If this were written into the service agreement there would be a tendency to abuse this clause. The following instance will illustrate this: In one case a switch was reported defective because the blade cross-bar was warped. The operator of the machine in shutting it down pulled the switch sufficient to break the contact on one phase only with the result that one phase of the motor was roasted. In this instance it was only necessary to refer to the report which called this defect to the attention of the customer and advised the repair of the switch. In this particular plant a contractor was doing the repair work and we were making inspections and reports only. This particular repair was made in due time but not until another motor had roasted out in a similar way. It is quite evident that a decided saving could have been affected if this customer had contracted in the beginning for our plan covering repair work as well as inspection. This was later brought about.

In order to explain how our schedule of rates is applied in contracting for this service, we will describe the charges for a particular customer, who happens to be a confectioner using 27 motors. These are d. c. motors and vary in size from fractional horsepower to 7½ hp. Upon gaining his interest in our service plans we obtained a list of the motors in service. When this was done we arranged them in horsepower classes according to the schedule outlined in plan No. 2, Table No. III. It will be noted at the bottom of the schedule that when starting equipment is used there is an addition to the motor fee of 10 per cent. The tabulation for this particular customer is shown above.

In this classification the total rate of $21.79 will be termed the whole rate. This whole rate is based on two inspections per month. It will be noted that a table of additions and deductions are a part of plan No. 2 in Tables II and III. These are applied in working out the final rate.



Considerable moisture in washing down is present in this installation of pasteurizers in an ice cream factory—a condition which demands inspection.

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Table I—Plan No. 1 Includes Inspections Only and Report

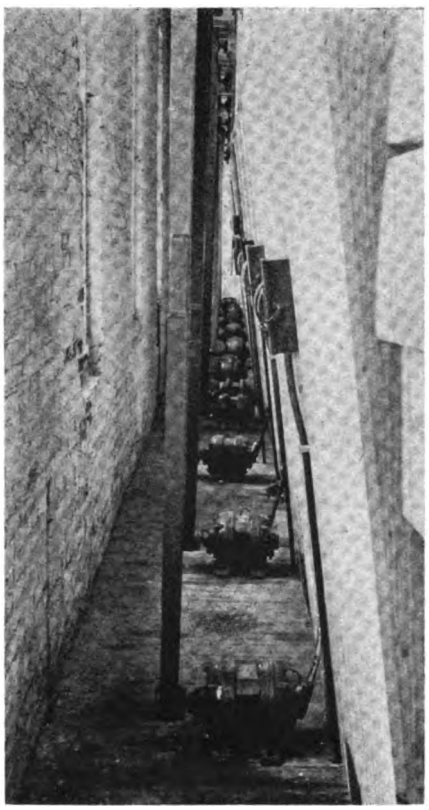
This plan is based upon two inspections per month and the report gives recommendations for changes necessary to safe and economical operation. The minimum rate is $10.00 per year.

Number of Motors	Rate per Motor per Month
5 to 10	$0.70
10 to 15	.65
15 to 20	.60
20 to 25	.55
25 to 30	.50
30 to 40	.45
40 to 50	.40

There are 27 motors in this installation which makes it fall in a class between 25 and 35 motors, calling for a reduction of 10 per cent from the whole rate. Thus $21.79 less $2.18 gives $19.61 as the base rate charged.

In determining the frequency of service required there are several points to consider; namely, (1) age of equipment, (2) care in handling it, (3) surroundings, (4) amount of usage.

In the case of this particular customer we found the equipment of comparatively recent make, operations in manipulation of equipment carefully handled, that there was little moisture close to the equipment and an average of 25 per cent usage was safe. We recommended a monthly service; this was considered sufficient, in view of the conditions.



This installation is of special interest because the motors operate 24 hours a day and there is no one in attendance from 6:30 p. m. to 7:00 a. m. The photograph shows 11 dryers in a macaroni factory. The apparent slanting of the walls is due to camera-distortion.

Table IV—Plan No. 3 Calls for an Oiling Service Only

Oiling is done twice a week. The minimum rate is $15.00 per year with the following schedule for groups of motors:

Number of Motors	Rate per Motor per Month
1 to 5	$0.80
5 to 10	.70
10 to 15	.65
15 to 20	.60
20 to 25	.55
25 to 30	.50
30 to 40	.45
40 to 50	.40
Over 50	Special rates

Since all rates in the tables accompanying this article are based on a semi-monthly service it is necessary to arrive at a rate that is just to the customer and to the service contractor for a monthly service. It is reasonable to expect and it is an absolute fact that a greater number of defects will result in thirty days than in fifteen days; therefore, it would be inconsistent to cut the rate in half.

Let us assume that we can place this inspection on the same dates with one of equal size and located somewhere near it. In this particular case this was actually done and we allowed a 5 per cent reduction from the base rate. Since operators are careful in handling equipment a further reduction of 10 per cent was allowed. Also since there was practically no moisture but some dust surrounding the equipment, a reduction of 5 per cent was made. For usage on the basis mentioned above a further reduction of 10 per cent was allowed, making a total reduction from the base rate of 30 per cent.

Since the base rate was figured as $19.61 the 30 per cent reduction gives the rate of charge for the service as $13.73 on the monthly service plan No. 2 outlined in Table No. III. But in this, as in all cases, the rates are made even so that in this particular instance the billed rate for the service was $13.00.

Tables II and III—Plan No. 2 Which Provides for More Service Than Plan No. 1

In addition to the work covered in Plan No. 1, this service plan includes oiling, wiping, adjustments and minor repairs that require little time.

Table No. II—A. C. Equipment		Table No. III—D. C. Equipment	
Horsepower	Rate	Horsepower	Rate
Fractional	$0.55	Fractional	$0.70
1 to 3	0.65	1 to 3	0.80
3 to 5	0.80	3 to 5	0.95
5	1.00	5	1.05
7½	1.15	7½	1.15
10	1.30	10	1.25
15	1.45	15	1.35
20	1.55	20	1.45
25	1.65	25	1.55
30	1.75	30	1.65
40	1.85	40	1.75
50	1.95	50	1.85
75	2.20	75	1.95
100	2.50	100	2.10
125	2.80	125	2.25

Rates are based on semi-monthly service.

For compensator, add	15 per cent	1 to 5 motors, add	15 per cent
For slip-ring equipment,	25 per cent	5 to 10 motors, add	10 per cent
For starter D. C.,	10 per cent	10 to 15 motors, add	5 per cent
		15 to 25 motors, deduct	5 per cent
		25 to 35 motors, deduct	10 per cent
		Over 35, special rates.	
		Minimum rate, $3.50 per month.	

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Table V—Information Compiled for Equipment Serviced

EQUIPMENT INSPECTED FOR RICHARD ROE & SON.

No.	Application	Maker	Serial	Frame Type	H.P.	R.P.M.	Volts	Phase	Cycles	Amps. per Terminal
1	Paper cutter	G. E.	1234235	K. T.	5	1800	220	3	60	13.
2	Saw trimmer	Holtzer-Cabot	334974	H.R. 1	¼	1750	110	1	60	5.
3	Cylinder Press No. 1	Allis-Chalmers	86441	A. N.	5	1800	220	3	60	14.

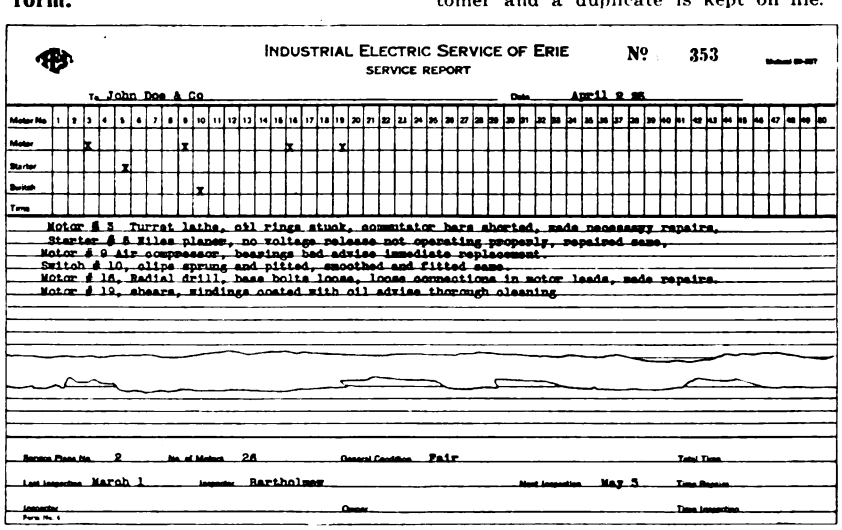
Table VI—Form Used to Indicate Time Consumed and Cost of Inspections and Repairs

This table is made up for a 12-motor job and weekly service. A time rate of 75 cents per hour is used with an overhead charge of 20 per cent.

Date of Inspection	3/15	3/22	3/30	4/7	4/13	4/21	4/28
Cost at 75c per hour	$1.50	$1.12	$1.87	$1.12	$0.37	$1.87	$0.37
Add overhead at 20 per cent	.30	.22	.37	.22	.07	.36	.07
Total cost	$1.80	$1.34	$2.24	$1.34	$0.44	$2.23	$0.44
Price of inspection	$2.81	$2.81	$2.81	$2.81	$2.81	$2.81	$2.81
Cost of inspection	1.80	1.34	2.24	1.34	.44	2.23	.44
Profit	$1.01	$1.47	$0.57	$1.47	$2.37	$0.58	$2.37

Report Form No. 2—Reports to customers are made up in this form.

This monthly report is made up from the inspection reports shown on page 288. The original goes to the customer and a duplicate is kept on file.


INDUSTRIAL ELECTRIC SERVICE OF ERIE
SERVICE REPORT
No. 353

To John Doe & Co. Date April 9 '08

Motor # 5 Turret lathe, oil rings stuck, commutator bars shorted, made necessary repairs.
Starter # 6 Niles planer, no voltage release not operating properly, repaired same.
Motor # 9 Air compressor, bearings bad advise immediate replacement.
Switch # 10, clips sprung and pitted, smoothed and fitted same.
Motor # 18, Radial drill, base bolts loose, loose connections in motor leads, made repairs.
Motor # 19, shears, windings coated with oil advise thorough cleaning.

Service Phone No. 2 No. of Motors 26 General Condition Fair Total Time
Last Inspection March 1 Inspector Bartholmew Next Inspection May 5 Time Required
Inspector Owner Time Inspection

We will assume now that the customer has accepted this rate and has made a contract for the service. The next step is to make up a detailed list of equipment included in the service. Such a list is shown in Table No. V. Each motor is numbered progressively through the plant and inspection routes are laid out in such a way as to eliminate retracing steps. This motor number is used to identify motors on all reports, records and correspondence.

This list often proves of value in saving trips to plants to get information in ordering repair parts and in case of oversight in taking nameplate data. It serves also as a check on additions to equipment that are made. A copy of this list is furnished to the customer and gives him a detailed list of his motor equipment which is something rarely found in the average size of plant.

When several plants are contracting for this service it is advisable to check up rates and correct any deficiency. Four plants were selected for this purpose as follows: A confectioner, a foundry, a printing establishment and an amusement park. A form was developed from data on time consumed in making inspections and repairs at frequent intervals and a tabulation worked up such as shown in Table No. VI. This particular table refers to a twelve-motor job which uses a weekly service.

It will be noted that from the first four inspections there was a very small profit; however, it will also be noted that on other inspections tabulated the profit was considerably larger, due to the inspector becoming familiar with the plant layout and the characteristics of the machines.

Table No. VI is based on an hourly rate of 75 cents and an overhead charge of 20 per cent. The writer believes the charges are reasonable when all things are taken into consideration. When making up this table it is necessary while on the job to note carefully the total time and the time on repairs. The difference represents the time devoted to inspection. By referring to the first column of Table No. VI, it will be noted that on March 15 the total time spent was two hours. The time taken by repairs was one hour and 24 minutes and the time by inspection 36 minutes. Four weeks later, April 13, the total time taken was 30 minutes with no repairs and 30 minutes for inspection. The profit in the first case was $1.01 and in the second, $2.39.

Cost averages may also be computed from Table No. VI and time averages per motor. These figures should be checked from time to time to indicate an increasing or falling off of profits.

No materials are included in the charge for our service. Such material as needed is furnished by us and billed in addition to the service charge.

On regular inspection trips the inspector carries individual motor report blanks such as the form shown as No. 1. *(Continued on page 324)*

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Practical Details and Tables for

Laying Out Unequal Groupings of Coils

In Induction Motors Having from Twenty to Twenty-Four Poles, Two and Three-Phase

THIS ARTICLE IS the fourth of a series by A. C. Roe on connecting induction motors. The other articles have appeared in the past three issues of INDUSTRIAL ENGINEER. They have dealt with the grouping of coils and the various connections required to give series and parallel windings. The present article shows tables and diagrams for twenty to twenty-four poles. It also describes a scheme for determining where the larger groups are placed in a winding which has unequal groups.

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company

IN THE MAY issue, pages 241 to 250, details were given for the laying out of unequal groupings of coils with special reference to securing a balance in the winding. In what follows the subject is continued from that issue with details given for induction motors of twenty to twenty-four poles, two and three phase.

"From the three-phase table for 4 to 48 poles, inclusive, and from 3 slots per pole up to 150 slots, the number of unequally grouped windings is about six times the number of equally grouped windings, which will be a considerable advantage to the designer. The different numbers of poles that may be wound with a given number of slots by using the unequal plus the equal groupings is considerably increased over the different numbers of poles that may be wound with equal groupings only. With four poles, for each possible winding in equal groups there are three windings in unequal groups. With eight poles there are seven unequal group windings for each equal group winding, and with ten poles the number of unequal group windings is nine times the number of equal group windings, and so on."

Table I—Example Showing How to Locate Coils in Unequal Groups

For such diagrams use section paper.
Three-phase; 20 poles; 144 slots; 60 phase groups.
Least common multiple for 144 slots and 60 phase groups is 720.
Slot interval, 5 spaces. Phase groups, 12 spaces. Pole groups, 36 spaces.

Pole No.	Phase A.	Phase B.	Phase C.
1	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .	. . 0 . . . . 0 0
2	. . . . 0 . . . . 0 . .	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .
3	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .
4	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .
5	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .	. . 0 . . . . 0 . . . .
6	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0
7	. . . . 0 . . . . 0 . .	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .
8	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .
9	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .
10	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .	. . 0 . . . . 0 . . . .
11	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0
12	. . . . 0 . . . . 0 . .	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .
13	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .
14	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .
15	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .	. . 0 . . . . 0 . . . .
16	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0
17	. . . . 0 . . . . 0 . .	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .
18	. . . 0 . . . . 0 . . .	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .
19	. . 0 . . . . 0	0 . . . . 0 . . . . 0 .	. . . 0 . . . . 0 . . .
20	. 0 . . . . 0 0	. . . . 0 . . . . 0 . .	. . 0 . . . . 0 . . . .

Number of coils in each phase group.

Pole No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Phase A	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3
Phase B	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2
Phase C	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2	3	3	2	2	2

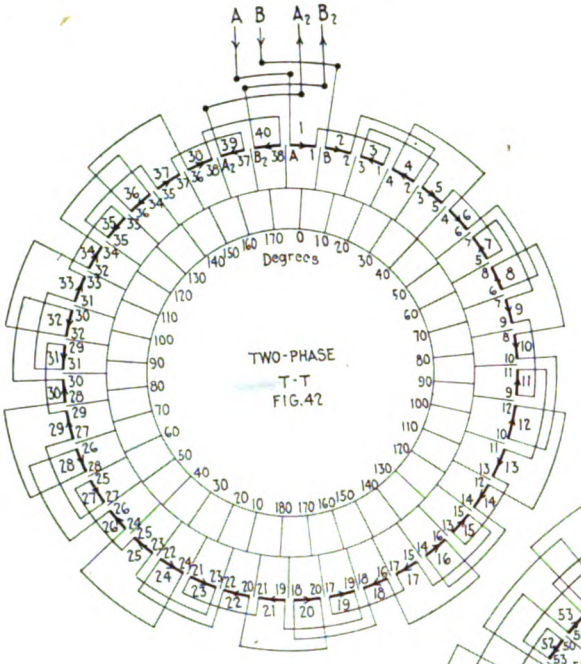
One side of each coil is represented in the diagram by 0. The other side of the coils is to be allowed for by the pitch factor. Coils under alternate poles must be reverse-connected.

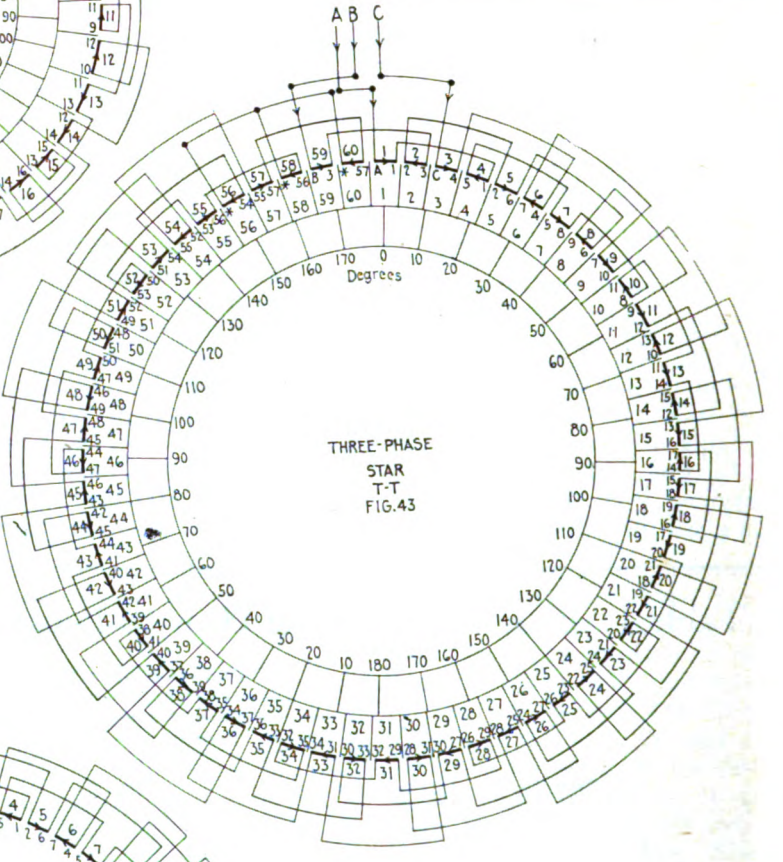
The above diagram shows that this winding may be connected in two or four multiple circuits, as the diagram forms four similar series for each phase. This winding may also be connected for two phases in which case the phase groups would be 18 spaces.

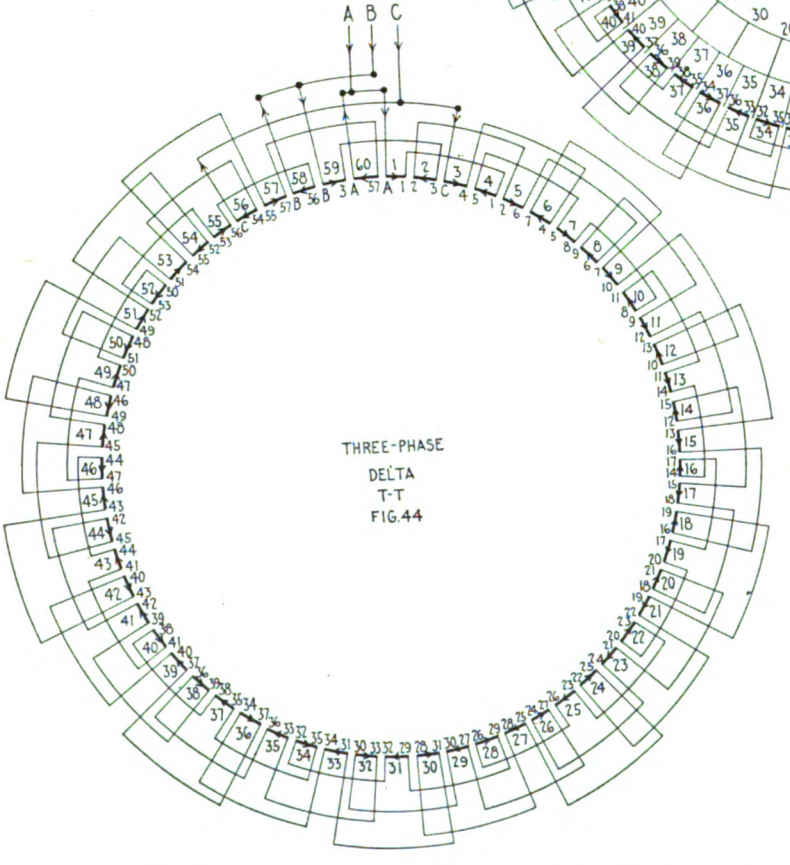
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Twenty-Pole Windings

See Tables on Pages 295 and 296 Showing the Corresponding Groupings and Method of Connecting Ends of Groups.







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Twenty-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, TOP-TO-TOP, CHART T

Coils	Group Numbers																												No. Large Groups	No. Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40		
48	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1									8	32
54	2^k 2	1 1	1 1	2 2	1 1	2 1	1 1	2 2	1 1	1 1	2 2^k	1 1	1 1	2 2	1 1	1 2	1 1	2 2	1 1	1 1									14	26
60	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1									20	20
62	2 2	1 1	2 2	2–1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 2–1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1									22	18
72	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2									32	8
84	3 2	2 2	2 2	2 2	2 2	2 3	2 2	2 2	2 2	2 2	3 2	2 2	2 2	2 2	2 2	2 3	2 2	2 2	2 2	2 2									4	36
86	3 2	2 2	2 2	3–1 2	2 2	2 3	2 2	2 2	2 2	2 2	3 2	2 2	2 2	2 3–1	2 2	2 3	2 2	2 2	2 2	2 2									6	34
90	3^k 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3^k	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2									10	30
96	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 2	2 2									16	24
104	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3	2 2	2 2	3 3	3 3	3 3									24	16
108	2 2	3 3	3 2	3 3	3 3	2 2	3 3	2 3	3 3	3 3	2 2	3 3	3 2	3 3	3 3	2 2	3 3	2 3	3 3	3 3									28	12
128	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	3 3	3 3										
135	4^k 4	3 3	4–1 3	4 4	3 3	4 3	3 3	4 4	3 3	3 3	4 4^k	3 3	3 3	4 4	3 3	3 4	3 3	4 4	3 3	3 3									15	25
144	3 3	3 3	4 4	4 4	4 4	3 3	3 3	4 4	4 4	4 4	3 3	3 3	4 4	4 4	4 4	3 3	3 3	4 4	4 4	4 4										
150	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4^k	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4^k 4	4 4									30	10
156	3 4	4 4	4 4	4 4	4 4	4 3	4 4	4 4	4 4	4 4	3 4	4 4	4 4	4 4	4 4	4 3	4 4	4 4	4 4	4 4									36	4
168	5 5	4 4	4 4	4 4	4 4	5 5	4 4	4 4	4 4	4 4	5 5	4 4	4 4	4 4	4 4	5 5	4 4	4 4	4 4	4 4										
180	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4										
216	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 5	5 5										

^{k}A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding.

THREE-PHASE, TOP-TO-TOP, CHART J

| Coils | Group Numbers | | | | | | | | | | | | | | | | | | |

Twenty-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 42

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17
2 Parallel																			A_2
4 Parallel									A_2	B_2	A	B							
5 Parallel							A_2	B_2	A 9	B 10	9	10							
10 Parallel			A_2	B_2	A	B					A_2	B_2	A	B	A_2	B_2	A	B	19
20 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A_2 A

Three-Phase Star, Top-to Top. See Fig. 43

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30
2 Parallel												*		*	B	*	A			C						*		*	B
4 Parallel																													
5 Parallel								*		*	B 12	*	A 14		12 C 16		14		16		*		*	B	*	A	27	C	29	27
10 Parallel		*		*	B	*	A		C			*		*		*	B	*	A	C							*		*	B
20 Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*

Three-Phase Delta, Top-to-Top. See Fig. 44

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30
2 Parallel												C		B	B	A	A		C							C		B	B
4 Parallel																													
5 Parallel								C		B	B 12	A	A 14		12 C 16		14		16		C		B	B	A	A	27	C	29	27
10 Parallel		C		B	B	A	A		C					C		B	B	A	A			C					C		B	B
20 Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C

Twenty-Two-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 45

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18
2 Parallel																			A_2	
11 Parallel			A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B		B_2
22 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A_2	B

Three-Phase Star, Top-to-Top. See Fig. 46

GroupNo.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30
2Parallel																													*		*	B
11Parallel		*		*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	30	*	A 32	* 30
22Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B

Three-Phase Delta, Top-to-top. See Fig. 47

GroupNo.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Series	A 1	2 63	C 3	4 1	2 5	6 3	4 7	8 5	6 9	10 7	8 11	12 9	10 13	14 11	12 15	16 13	14 17	18 15	16 19	20 17	18 21	22 19	20 23	24 21	22 25	26 23	24 27	28 25	26 29	30 27	28 31	32 29
2Parallel																													C		B	B
11Parallel		C		B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	29	A	A 31	C 29
22Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B

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tion Motor Windings

——————Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*)

Two-Phase (Continued)

20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
20 18 B_2	19 21 A	20 22 B	23 21	24 22	23 25	24 26	27 25	28 26	27 29 A	28 30 B_2	31 29 A	32 30 B	31 33	32 34	35 33	36 34	35 37	36 38	A_2 37	B_2 38
20 B_2 B	19 A A_2	20 B B_2	A_2 A	B_2 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	30 B B_2	A_2 29 A	B_2 30 B	A A_2	B B_2	A_2 A	B_2 B	A A_2	B B_2	A	B

Three-Phase Star (Continued)

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
31 28 *	29 32 A	33 30	31 34 C	35 32	33 36	37 34	35 38	39 36	37 40	41 38	39 42 *	43 40	41 44 *	45 42 B	43 46 *	47 44 A	45 48	49 46 C	47 50	51 48	49 52	53 50	51 54	55 52	53 56	* 54	55 57	* 56	B 3	* 57
31 * C	29 A *	* B	31 C *	* A	B *	* C	A *	* B	C *	* A	42 B *	* C	A *	44 *	42 B C	46 *	44 A *	B *	* 46 C	A *	* B	C *	* A	B *	* C	A *	* B	C *	* A	* C

Three-Phase Delta (Continued)

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
31 28 A	29 32 A	33 30	31 34 C	35 32	33 36	37 34	35 38	39 36	37 40	41 38	39 42 C	43 40	41 44 B	45 42 B	43 46 A	47 44 A	45 48	49 46 C	47 50	51 48	49 52	53 50	51 54	55 52	53 56	C 54	55 57	B 56	B 3	A 57
31 A C	29 A B	C B	31 C A	B A	B C	A C	A B	C B	C A	B A	B C	42 A C	A C	44 B	C 42 B	46 A	B 44 A	B C	A 46 C	A B	C B	B A	B A	A C	A C	B	C B	A	A	C	C

tion Motor Windings

——————Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*)

Two-Phase, Top-to-Top (Continued)

21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
19 21 A_2 A 21 A_2	20 22 B_2 B 22 B_2	23 21 A A_2 21 A	24 22 B B_2 22 B	23 25 A A_2	24 26 B B_2	27 25 A_2 A	28 26 B_2 B	27 29 A A_2	28 30 B B_2	31 29 A_2 A	32 30 B_2 B	31 33 A A_2	32 34 B B_2	35 33 A_2 A	36 34 B_2 B	35 37 A A_2	36 38 B B_2	39 37 A_2 A	40 38 B_2 B	39 41 A A_2	40 42 B B_2	A_2 41 A	B_2 42 B

Three-Phase Star (Continued)

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
31 34 * C 34 *	35 32 A * 32 A	33 36 B *	37 34 C * 34 C	35 38 A *	39 36 C *	37 40 B *	41 38 A *	39 42 C *	43 40 A *	41 44 B *	45 42 C *	43 46 A *	47 44 B *	45 48 C *	49 46 A *	47 50 B *	51 48 C *	49 52 A *	53 50 B *	51 54 C *	55 52 A *	53 56 B *	57 54 C *	55 58 A *	59 56 B *	57 60 C *	61 58 A *	59 62 C *	* 60 B *	61 63 C *	* 62 A *	B 3 *	* 63 C

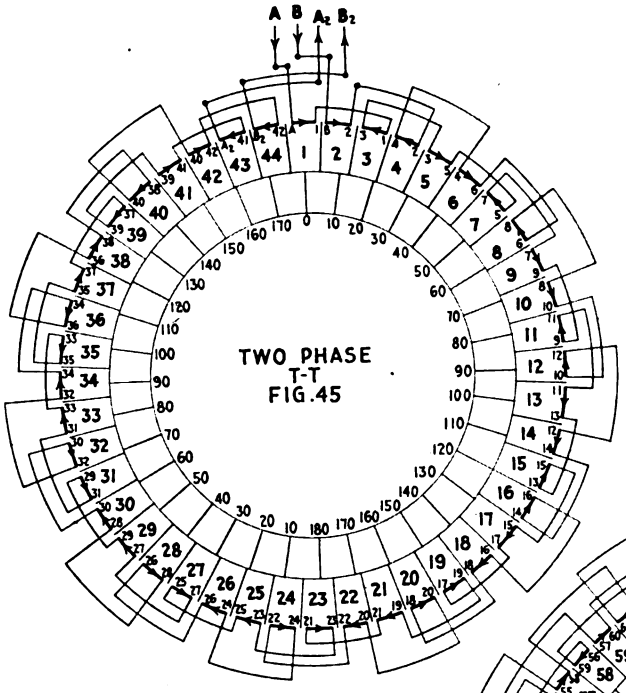
Three Phase Delta (Continued)

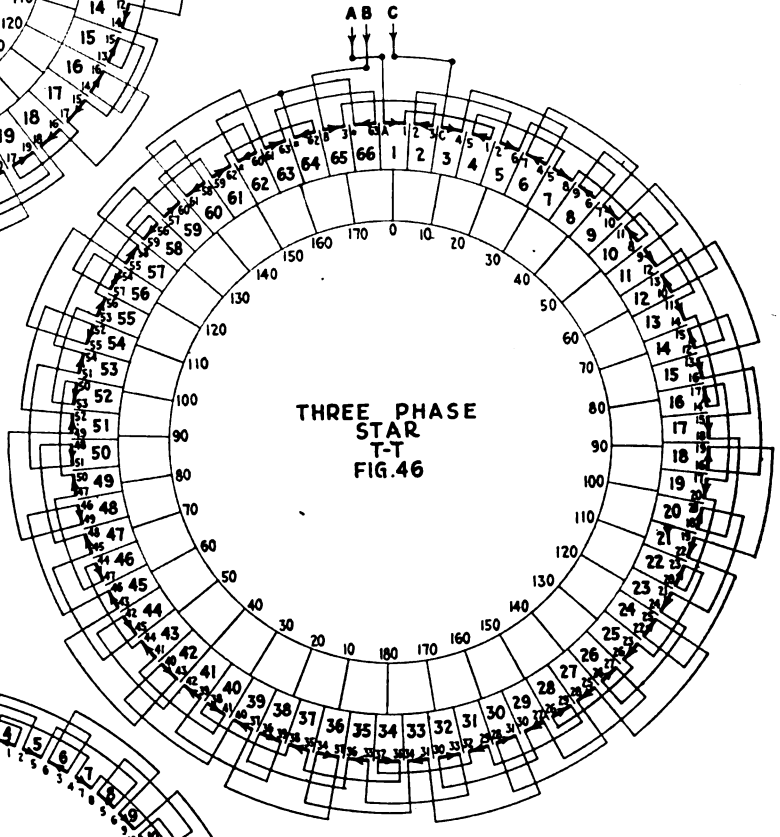
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
30 33 A C 33 A	34 31 A B 32 A	32 35 B C	36 33 C A 33 C	34 37 A B	38 35 C B	36 39 C A	40 37 B A	38 41 B C	42 39 A C	40 43 A C	44 41 C B	42 45 C B	46 43 B A	44 47 B A	48 45 A C	46 49 A C	50 47 C B	48 51 C B	52 49 B A	50 53 B A	54 51 A C	52 55 A C	56 53 C B	54 57 C B	58 55 B A	56 59 B A	60 57 A C	58 61 A C	C 59 C B	60 62 C B	B 61 B A	B 63 A C	A 62 C

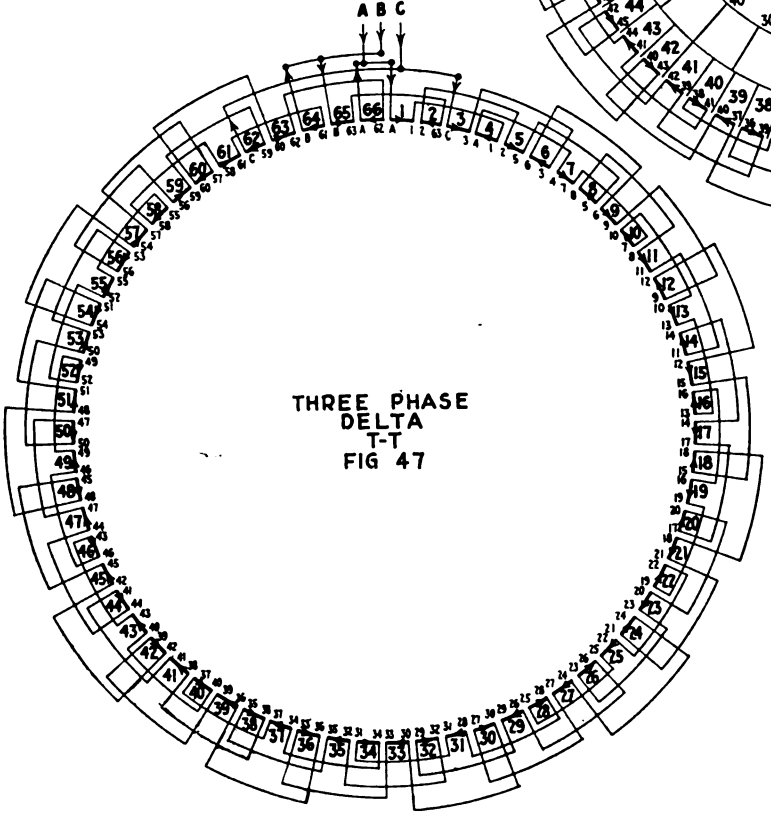
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Twenty-Two-Pole Windings

See Tables on Pages 299 and 296 Showing the Corresponding Groupings and Methods of Connecting Ends of Groups.







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Twenty-Two-Pole Windings—Unequal Coil Grouping

TWO-PHASE. TOP-TO-TOP. CHART V

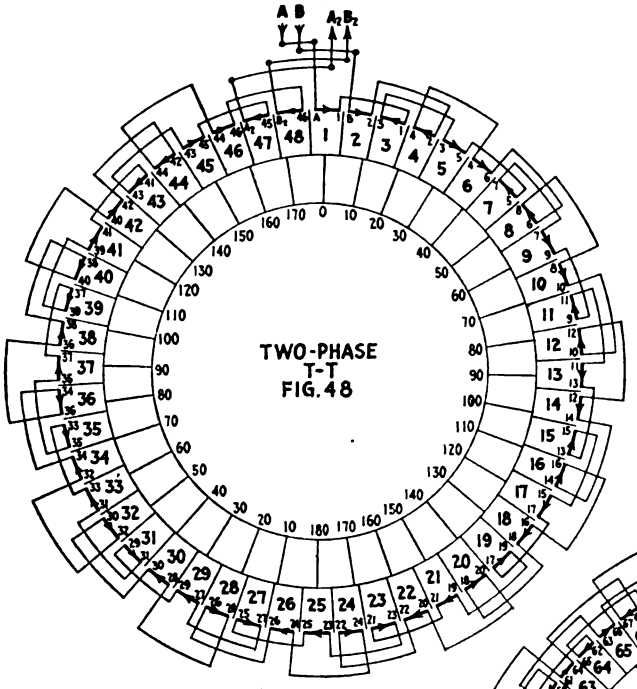
No. Coils	Group Numbers.																																		No. Large Groups	No. Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40	41 42	43 44														
54	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	2k 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 2k	1 1	1 1													10	34
60	2 2	1 1	1 2	2 1	1 1	2 2	1 1	1 1	2 2	1 1	1 1	2 2	1 1	1 2	2 1	1 1	2 2	1 1	1 1	2 2	1 1	1 1													16	28
62	2 2	1 1	1 2	2 1	1 1	2 2	1 1	2–1 1	2 2	1 1	1 1	2 2	1 2–1	1 2	2 1	1 1	2 2	1 1	1 1	2 2	1 1	1 1													18	26
72	1 1	2 2	2 1	1 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 1	1 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2													28	16
80	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2													36	8
84	1 2	2 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	2 2	2 2	1 2	2 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	2 2	2 2													40	4
86	1 2k	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 -2	2k 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2													42	2
90	3k 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 3k	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2 2													2	42
96	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2													8	36
104	3 3	2 2	2 3	3 2	2 2	3 3	2 2	2 2	3 3	2 2	2 2	3 3	2 2	2 3	3 2	2 2	2 3	3 2	2 2	3 3	2 2	2 2														
108	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 3	3 2	2 2	3 3	3 3	2 2	2 2	2 2	3 3	3 3	2 2	2 3	3 2	2 2													20	24
120	2 2	3 3	3 3	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	3 3	3 3	3 3	3 3	2 2	3 3	3 3	2 2													32	12
128	2 3	3 3	3 3	3 3	3 3	3 2	3 3	3 3	3 3	3 3	3 3	2 3	3 3	3 3	3 3	3 3	3 2	3 3	3 3	3 3	3 3	3 3														
135	4k 3	3 3	3 3	3 3	3 3	3 3	4–1 3	3 3	3 3	3 3	3 3	3 4k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3	3 3													3	41
144	4 4	3 3	3 3	3 3	4 4	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3													12	32
150	4 4	3 3	3 4	4 3	3 3	4 4	3 3	4–1 3	4 4	3 3	3 3	4 4	3 4–1	3 4	4 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3														
156	3 3	3 3	4 4	4 4	4 4	3 3	3 3	4 4	4 3	3 4	4 4	3 3	3 3	4 4	3 3	4 4	3 3	4 4	4 3	3 4	4 4	3 3													24	20
160	3 3	4 4	4 3	3 4	4 4	3 3	4 4	4 4	3 3	4 4	4 4	3 3	4 4	4 3	3 4	4 4	4 3	3 4	4 4	4 4	3 3	4 4														
168	3 3	4 4	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	3 3	4 4	4 4	4 4	4 4	4 4														
180	5k 4	4 4	4 4	4 4	4 4	4 5k	4 4	4 4	4 4	4 4	4 4	5k 4	4 4	4 4	4 4	4 4	4 5k	4 4	4 4	4 4	4 4	4 4													4	40
216	4 5	5 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5	5 5	5 5	4 5	5 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5	5 5	5 5														
240	6 6	6 6	5 5	5 5	5 5	6 6	6 6	5 5	5 6	6 5	5 5	6 6	6 6	5 5	5 5	9 5	6 6	6 6	5 5	5 6	6 5	5 5														

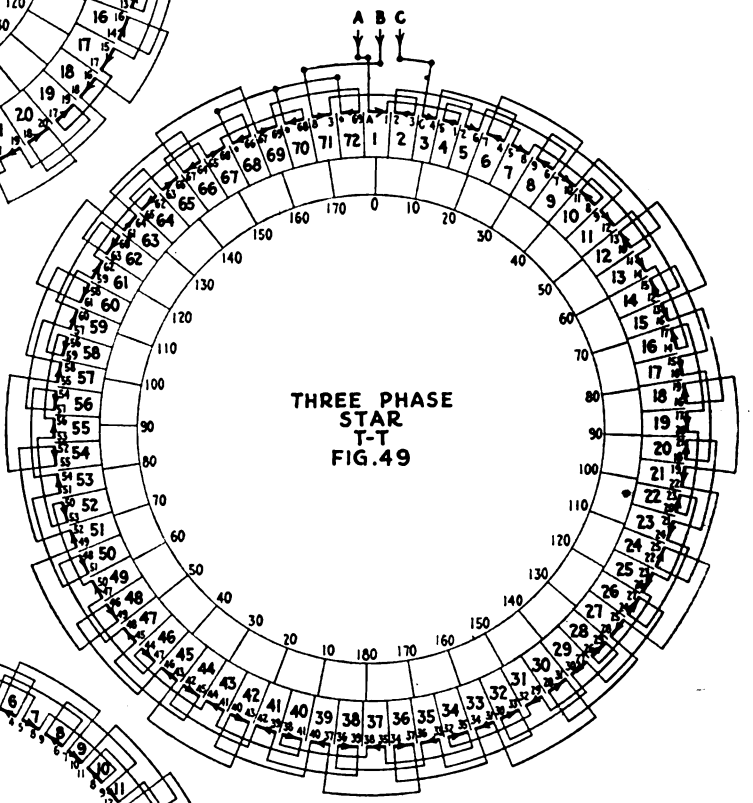
THREE-PHASE. TOP-TO-TOP. CHART U

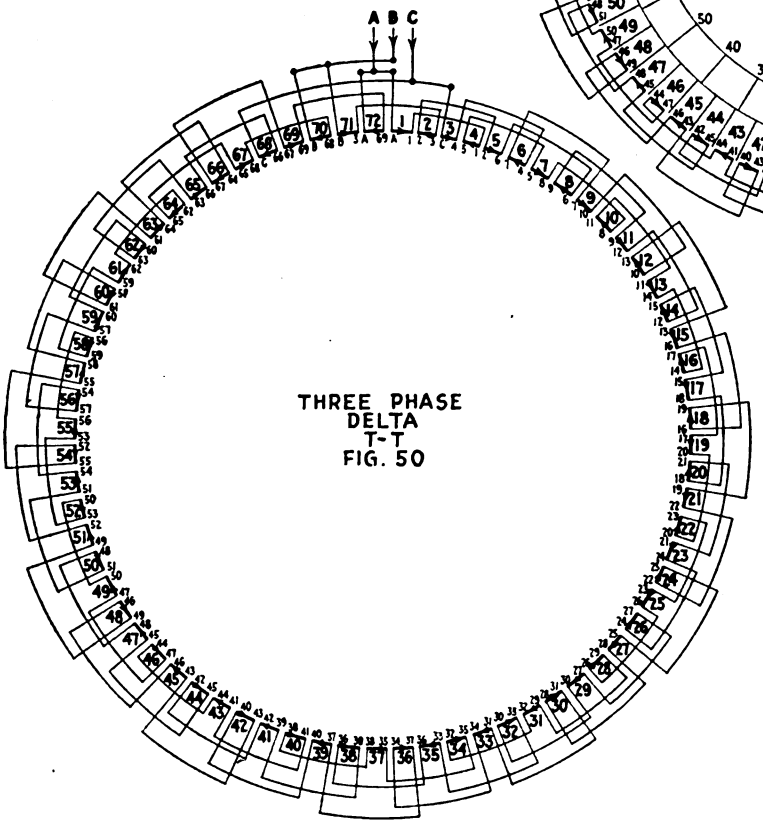
| No. Coils | Group Numbers | | | | | | | | | | | | | | | | | | |

Twenty-Four-Pole Windings

See Tables on Pages 301 and 302 Showing the Corresponding Groupings and Methods of Connecting Ends of Groups.







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Twenty-Four-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE. TOP-TO-TOP. CHART W

No. Coils	Group Numbers																																		No Large Groups	No Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34	35 36	37 38	39 40	41 42	43 44	45 46	47 48												
54	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1	2 2	1 1	1 1	1 1	1 1	1 1	1 1	1 1											6	42
60	2 2	1 1	1 1	1 1	2^k 2^k	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2^k 2^k	1 1	1 1	1 1	2 2	1 1	1 1	1 1											12	36
62	2 2	1 1	2-1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 2-1	1 1	2 2	1 1	1 1	1 1	2 2	1 1	1 1	1 1											14	34
72	2 2	1 1	2 2	1 1	2 2	1 L	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1											24	24
80	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2											32	16
84	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2											36	12
86	1 1	2 2	2 2	2 2	1 2-1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2	1 1	2 2	2 2	2 2											38	10
90	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2	2-1 1	2 2	2 2	2 2	2 2	2 2	2 2	2 2											42	6
104	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2	3 3	2 2	2 2	2 2	2 2	2 2											8	40
108	3 3	2 2	2 2	2 2	3^k 3^k	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3^k 3^k	2 2	2 2	2 2	3 3	2 2	2 2	2 2												
120	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2												
128	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	3 3	2 2	3 3	2 2	3 3	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	3 3	2 2												
135	2 2	3 3	3 3	3 3	2 2	3 3	3 3	3 3	3 3	3 3	2 2	3 3	3 3	3 3	2 3-1	3 3	3 3	3 3	3 3	3 3	2 2	3 3	3 3	3 3												
150	4^k 4^k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	3 3	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	3 3	3 3	3 3	3 3											9	39
156	4 4	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4^k 4^k	3 3	3 3	3 3	4 4	3 3	3 3	3 3												
160	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3	4 4	3 3	3 3											16	32
168	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3	4 4	3 3												
180	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4												
216	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4												

[k] A coil is killed in each group where this symbol appears, provided it appears also in the Main Table for this winding.

UNEQUAL COIL GROUPING

THREE-PHASE. TOP-TO-TOP CHART O

| No. Coils | Group Numbers | | | | | | | | | | | | | | | | | | |

An even greater number of windings, about twice as many, is possible if the windings already mentioned are included. These are the windings which are practically satisfactory, although not absolutely balanced according to Mr. Tingley.

Furthermore, it is possible to get still more combinations by killing coils or leaving slots empty as already outlined in the April issue of INDUSTRIAL ENGINEER.

"With 108 slots balanced three-phase windings may be made for any number of poles met with in ordinary practice, besides a number of two-phase windings. This is of great practical value in induction motor designing as standard or existing punchings may be used for special motors. In two- and three-speed induction motors, using one, two or three primary windings, it will greatly facilitate the design by allowing a greater choice in the number of slots that may be used.

"A fourteen-pole, three-phase, 126-slot, squirrel-cage induction motor may be carrying a certain load which will permit a desirable increase or decrease in speed. Usually this would require a new motor, but Table II, on page 243 of the May issue, shows that, so far as the stator slots are concerned, stator windings for eight, ten, twelve or sixteen poles could be applied. Possibly simply reconnecting the old stator windings for twelve or sixteen poles would be practicable.

"A desirable generator winding often requires a few more or less conductors than may be obtained in equal groups per phase per pole, and a small increase or decrease in the number of slots would permit the use of the winding. If in designing a twenty-pole, 120-slot, three-phase generator it is found that a winding having two conductors per slot is very desirable, but that this would give about 10 per cent too few or too many conductors, the larger number of conductors may be employed by using fractional-pitch coils and 120 slots. But there may be no way of increasing the smaller number of conductors except by making a very undesirable winding. However, by using unequal groups of coils the number of slots may be increased or decreased to any extent in steps of three, and the number of conductors thereby properly adjusted.

"Any of these three-phase windings may be connected in star or delta. They may also be connected in multiple circuits where the series of coils permit.

"With lap windings the number of coils is equal to the number of slots, but similar relations may also be applied to chain and basket windings where the number of coils is half the number of slots. Chain windings have certain advantages for high-voltage coils, but they are seldom used for three phases with an odd number of pairs of poles on account of the special or 'twisted' coils required. By using a suitable number of slots, in many cases a three-phase chain winding for an even number

Twenty-Four-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 48

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17	16 18	19 17	20 18	19 21	20 22
2 Parallel																						
3 Parallel															A_2	B_2	A	B				
4 Parallel											A_2	B_2	A	B	15	16	15	16				
6 Parallel							A_2	B_2	A	B	11	12	11	12	A_2	B_2	A	B				
8 Parallel					A_2	B_2	7 A	8 B	7	8	A_2	B_2	A	B	15	16	15 A_2	16 B_2	A	B		
12 Parallel			A_2	B_2	A 5	B 6	A_2 5	B_2 6	A	B					A_2	B_2	A 17	B 18	A_2 17	B_2 18	A	B
24 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2

Three-Phase Star, Top-to-Top. See Fig. 49

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Series	A 1	2	3 C	4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30	31 34	35 32
2 Parallel																																	•		•
3 Parallel																				•		•	B	•	A		C						33		35
4 Parallel														•		•	B	•	A	21	C	23	21	25	23		25						•		•
6 Parallel								•		•	B	•	A	15	C	17	15	19	17	•	19	•	B	•	A		C								
8 Parallel		•		•	•		•	9 B	•	11 A	9	13 C	11	•	13	•	B	•	A	21	C	23	21 •	25	23 •	B	25 •	A		C					
12 Parallel					B 6	•	A 8	• 6	C 10	• 8	B	• 10	A		C					•		•	B 24	•	A 26	•	24	C 28	•	26	B	•	28	A		C	
24 Parallel	•	B	•	A	•	C	•	B	•	A	•	C	•	B	•	A	•	C	•	B	•	A	•	C	•	B	•	A	•	C	•	B	•	A	•

Three-Phase Delta, Top-to-Top. See Fig. 50

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Series	A 1	2	3 C	4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24	25 28	29 26	27 30	31 28	29 32	33 30	31 34	35 32
2 Parallel																																	C		B
3 Parallel																				C		B	B	A	A		C						33		35
4 Parallel															C		B	B	A	21	C	23	21	25	23		25						C		B
6 Parallel								C		B	B	A	A	15	C	17	15	19	17	C	19	B	B	A	A		C								
8 Parallel					C			9 B	A	11 A	9	13 C	11	C	13	B	B	A	A	21	C	23	21 C	25	23 B	B	25 A	A		C					
12 Parallel		C		B	B 6	A	A 8	C 6	C 10	B 8	B	A 10	A		C					C		B	B 24	A	A 26	C 24	C 28	B 26	B	A 28	A		C	
24 Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C

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of pairs of poles may be connected for an odd number of pairs of poles. As an example, a twenty-pole, 120-slot sixty-coil, three-phase chain winding may be connected for fourteen poles.

"A fractional number of slots per pole will have a tendency, in generators with accurately spaced poles, to reduce the magnetic locking and thereby the magnetic losses, especially with a small number of open slots per pole. In generators having a fractional number of open slots per pole the poles should be accurately spaced at the faces; for otherwise the voltage generated may vary with the position of the poles, especially with a small number of slots per pole, and thin-filament incandescent lamps operated from such a generator may flicker.

"In split-frame machines special attention must be given to the practicable relations of slots and punching segments to have them built properly at the split in the frame. Where segmental slot dies are used it may be difficult to adapt the required number of slots to segments of acceptable size. In some cases this may be accomplished by arranging to build the punchings spirally. With segments blanked out and with indexed slots the difficulties may not be so great, although an excessively large number of different segments may result.

"Unequally grouped windings will have a tendency to improve the wave forms by substituting a large number of small ripples for a few large ones, as produced by the equally-grouped windings. Fractional group windings, however, reduce the form factor of the wave as they give the effect of a large number of slots per pole as regards wave-form.

"Table I is a sample diagram showing how the coil groups for the poles and phases may be readily determined. It is simply a scale that is divisible a whole number of times by the number of phase groups and slots. The number of phase groups is the number of phases times the number of poles. The number of scale divisions is the least common multiple of the number of slots and phase groups. It may then be termed a Least-Common-Multiple diagram. It may be in circular form, or in tabular form as written on a typewriter, or it may be very quickly written out on section paper. Section paper is the most convenient and the tabular form preferable, with the phase groups in vertical columns, as the possibilities of multiple connections may be more easily noted by inspection. Two or more similar series of coil groups in a phase may be connected in multiple. The use of multiple circuits is often important for magnetic balancing and also for making changes in voltage."

In making the diagram on section paper the pole numbers are each put down as shown in the column at the left. Then to the right of each of these numbers is placed a scale represented by a number of dots. This number *(Continued on page 325)*

tion Motor Windings

Correct together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*)

Two-Phase (Continued)

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
23 21	24 22	23 25	24 26	27 25	28 26	27 29	28 30	31 29	32 30	31 33	32 34	35 33	36 34	35 37	36 38	39 37	40 38	39 41	40 42	43 41	44 42	43 45	44 46	A2 45	B2 46
A2	B2	A	B																						
23	24	23	24					A2	B2	A	B														
A2	B2	A	B					31	32	31	32	A2	B2	A	B										
						A2	B2	A2	B2	A	B	35	36	35	36	A2	B2	A	B						
				A2	B2	A 29	B 30	31 A	32 B	31	32	A2	B2	A	B	39	40	39 A2	40 B2	A	B				
A	B	A2	B2	A	B	A2	B2	A2 29	B2 30	A	B					A2	B2	A 41	B 42	A2 41	B2 42	A	B		
								A	B	A2	B2	A	B	A2	B2	A	B	A2	B2	A	B	A2	B2	A	B

Three-Phase Star (Continued)

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
37 34	35 38	39 36	37 40	41 38	39 42	43 40	41 44	45 42	43 46	47 44	45 48	49 46	47 50	51 48	49 52	53 50	51 54	55 52	53 56	57 54	55 58	59 56	57 60	61 58	59 62	63 60	61 64	65 62	63 66	67 64	65 68	* 66	67 69	* 68	B 3	* 69
*	A		C																																	
37	35		37					*		*	B	*	A		C																					
*	A		C					45		47	45	49	47	*	49	*	B	*	A		C															
								*		*	B	*	A	51	C	53	51	55	53	*	55	*	B	*	A		C										
						*		45 B		47 A	45	49 C	47	*	49	*	B	*	A	57	C	59	57 *	61	59 *		B 61	*	A		C							
		*		*	B 42	*	A 44	* 42 C	46	* 44	B	* 46	A		C		B		A		C		*	B 60	*	A 62	*	B 60	C 64	* 62	B	* 64	A		C		
C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C

Three-Phase Delta (Continued)

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
37 34	35 38	39 36	37 40	41 38	39 42	43 40	41 44	45 42	43 46	47 44	45 48	49 46	47 50	51 48	49 52	53 50	51 54	55 52	53 56	57 54	55 58	59 56	57 60	61 58	59 62	63 60	61 64	65 62	63 66	67 64	65 68	C 66	67 69	B 68	B 3	A 69
A	A		C																																	
37	35		37					C		B	B	A	A		C																					
A	A		C					45		47	45	49	47	C	49	B	B	A	A		C															
								C		B	B	A	A	51	C	53	51	55	53	C	55	B	B	A	A		C										
							B	45 B		A 47	A 45	49 C	47	C	49	B	B	A	A	57	C	59	57 C	61	59 B		B 61	A	A		C							
		C				C	B 44	C 42	C	46	B 44	A 46	A		C							B	B 60	A	A 62	C	B 60	C 64	B 62	B	A 64	A		C		
C	B	B	A	A	B	C	A	B	A	A	A	C	B	B	A	A	C	C	B	B	A	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C

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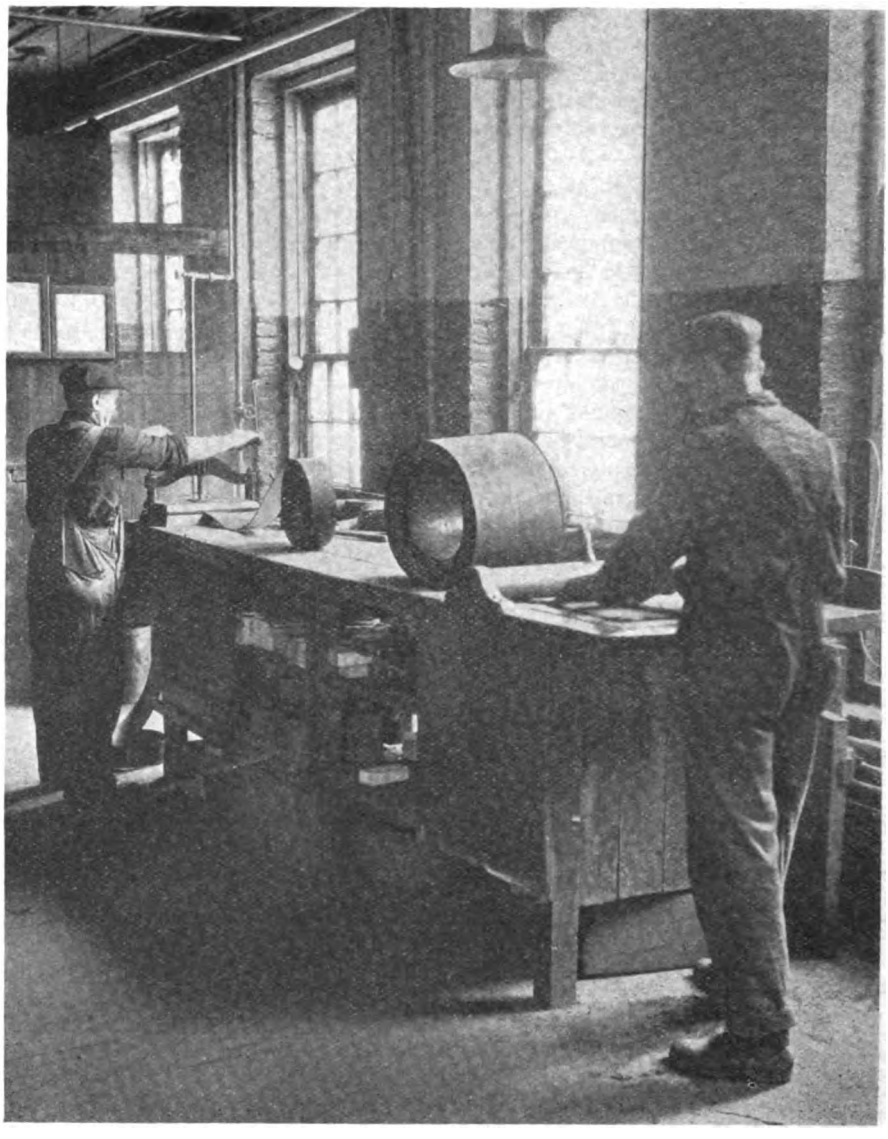
WHEN A LEATHER BELT becomes worn, oily or opens at the laps, industrial works usually discard them and buy new. However, these may be cleaned and cut down or rebuilt, if necessary, with a saving of at least 15 per cent or more in the annual belt bill. Some of the methods of reclaiming belts and their advantages are given in this article.

Some of the Hows and Whys of

Reclaiming Leather Belts

Methods That May Be Used to Reduce Operating and Maintenance Costs by Reusing Discarded Belts

By FRANK E. GOODING
Associate Editor, Industrial Engineer



This and several of the accompanying photographs were taken in the belt shop of the Deering Works of the International Harvester Company. Here two men reclaim, repair and install all belts as explained in this article.

ESTIMATES resulting from an investigation of scrapped leather belts in industrial plants show that about 65 per cent of the belting that is discarded has in it a period of useful life still that is worth while to reclaim. Even though it is not reclaimed, leather belts still have a scrap value of 25 cents or more per pound, depending on the leather market. Trimmings, cracked, burned, or worn-out sections and other parts not worth working up into new belting, also have a small scrap value. However, it usually pays to use up this scrap around the factory instead of selling it. For example, such scrap pieces may be used for shoe soles in foundries, for hand leathers, and many other purposes for which, in altogether too many cases, new pieces of leather belting are used. Also small scraps may be used in casehardening.

Almost any industrial plant can save 15 per cent or more of its annual leather belt bill if the men in the plant fully understand and apply the practical principles of cutting down and reclaiming this discarded leather belting. Most leather belt manufacturers will overhaul and rebuild belts. Also several concerns specialize on this type of work and have special facilities and ability based on wide experience. In one plant, for example, the belt bill has been reduced about 50 per cent. That this concern is still maintaining a saving in belt costs is shown by the fact that another plant of about the same size, which makes a similar product, has an annual belt expense of more than double. In computing this saving only the actual belt costs are used. No allowance whatever is made for the decrease in number of shutdowns and its resulting increase in production, factors which can only be estimated. Later in this article more will be given on methods that can be used to decrease belting expenses.

In every industrial works the man responsible for belt maintenance should acquire a good working knowledge of leather and how belts are made. He should also study the service requirements of different installations that require a belt rating larger than ordinarily might be expected. This experience will help him to judge what is wrong with a belt when it gives way under service conditions earlier than might be expected. It should always be an established rule, whenever a belt gives way in service, to find out why it gave way before it is replaced by another belt. When this is done any projecting edges or points which scrape or rub on the belt may be

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removed, pulleys that are loose or out of line may be lined up properly, a belt that is too weak replaced by a heavier one, and other factors eliminated which interfere with the effective operation of the belt and shorten its life.

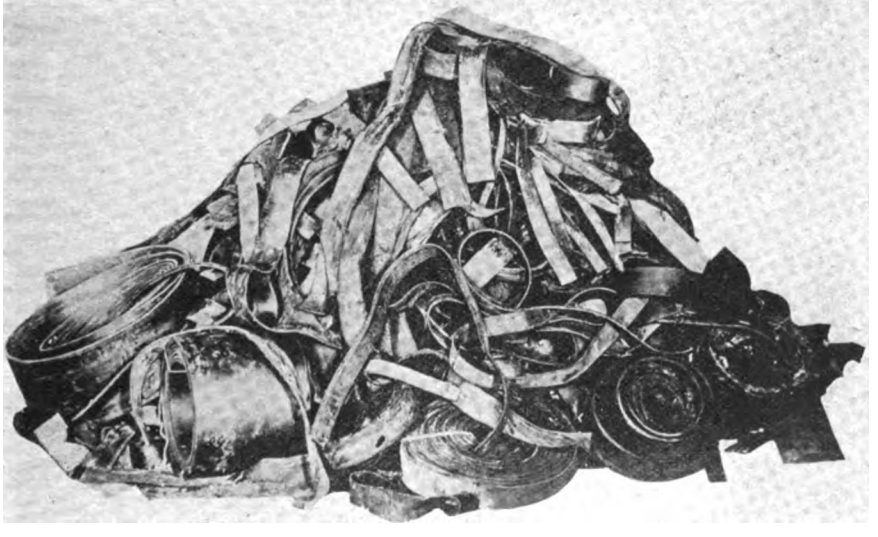
One of the things to look for when a belt is removed from service is to see how badly and where it is worn. It is also necessary to look out for open plies and joints as well as rough or torn edges. Oil and dirt are other factors which interfere with good belt service and should be taken care of before a belt is put back into service. Not only will a dirty belt slip again when returned to service but a belt filled with oil and grease cannot be cemented together properly. If a belt cracks when it is bent double with the pulley side out, this indicates that the belt has been burned by slipping over the pulley or that it is very dry. Ordinarily but little can be done when a belt has been burned except that the damaged sections must be cut out and thrown away. In double or 3-ply belts usually only the ply next to the pulley is damaged. This can be removed and replaced. If the belt is too dry, it can be softened by using a special belt oil. Castor or neatsfoot oil, tallow, or some of the special preparations in stick or wax form can be used for softening belts. This point was covered in the article entitled "Servicing Industrial Belts" which appeared in the May issue of INDUSTRIAL ENGINEER. The greatest trouble in using these generally lies in applying too much oil or dressing, which may be worse than not enough.

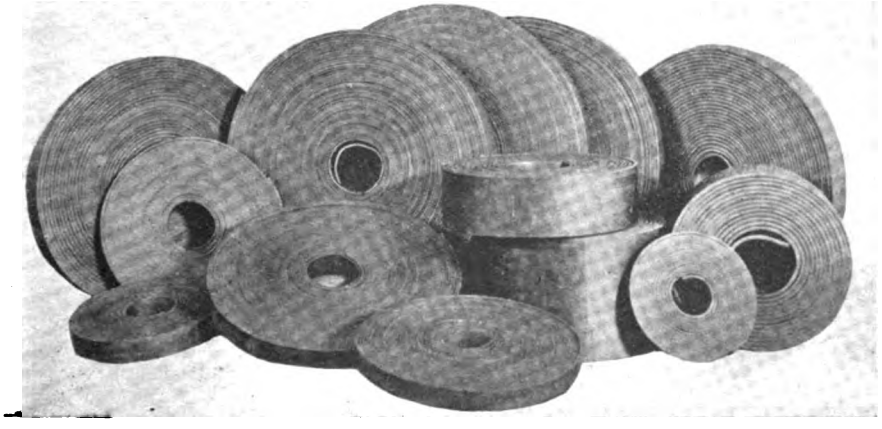
What May Be Done to Reclaim Leather Belts

One of the most common injuries to belts which an industrial belt man is called upon to treat, is a belt worn on the edge or face. For example, practically all belts that are shifted get thick at the edge. Roller shifters decrease the damage and make a belt last longer on this work. Also, it is not unusual to find a belt rubbing against a board which is put up to keep the belt on the pulley. A belt cannot cut several inches into this board without damage to itself. The remedy here is to align the pulleys or cut the ends of the belt square so that the board is not necessary. This, however, is one of the easiest problems of reclamation for the belt man. Usually with ½ in. cut off the edges of the belt a good serviceable belt of 1-in. narrower width is reclaimed. Of course, there may be other repairs to make such as replacing worn sections or regluing laps and joints. Sometimes, however, one edge is so badly damaged that more than ½ in. needs to be cut away.

Where belts are allowed to scrape or rub, this simply wears away the belt until much of the strength is gone. To repair such a belt it is sometimes necessary to cut a 3-ply down to a double belt by removing one ply or, on a double belt, to make it into a single belt. Usually when single belts are worn away in this manner they are hardly worth repairing although if not too badly worn a ply may be added which gives a strength equal to a light double or heavy single belt. Also, when a belt rubs either on the sides or at the edge, it is likely that the fastening will catch and open up or tear out unless it happens to be a cemented endless belt.

Frequently one of the first steps in handling a leather belt is to clean it. This may be done either on the pulley or when removed, but a belt is much easier to clean and a much better job can be done if it is off the pulley. Belts may be cleaned on the pulley by applying gasoline with a brush or waste soaked in high-grade gasoline or naphtha. Because of static the belt should be idle. Within a few minutes, after the gasoline has had time to soak into the belt, the dirt and oil may be removed by scraping with a block of wood or any blunt-edged tool held so that it will not catch and cut the belt. In some cases it may be necessary to apply more than one coating of gasoline before a belt is clean. This method is not recommended because of the fire hazard. Also many belts are so well guarded that it is almost impossible to get at them to clean in this way and it is unsafe to operate without the guard.





A pile of discarded leather belting and what was made from it.

The maintenance engineer in one industrial plant, rather skeptically sent the 1,726 lb. of junk leather belting shown in the upper of the two photographs to a "Belt Laundry" to see what he could get out of it. He received back the pile of good, usable belting worth at that time $1,300, which is shown in the lower of the two illustrations. There was a loss of 517 lb. or 30 per cent, due to metal belt fasteners, dirt and oil which were removed. Some of this reclaimed belting is still in service, ten years after it was cleaned up. Photographs by courtesy of F. Raniville Company, Grand Rapids, Mich.

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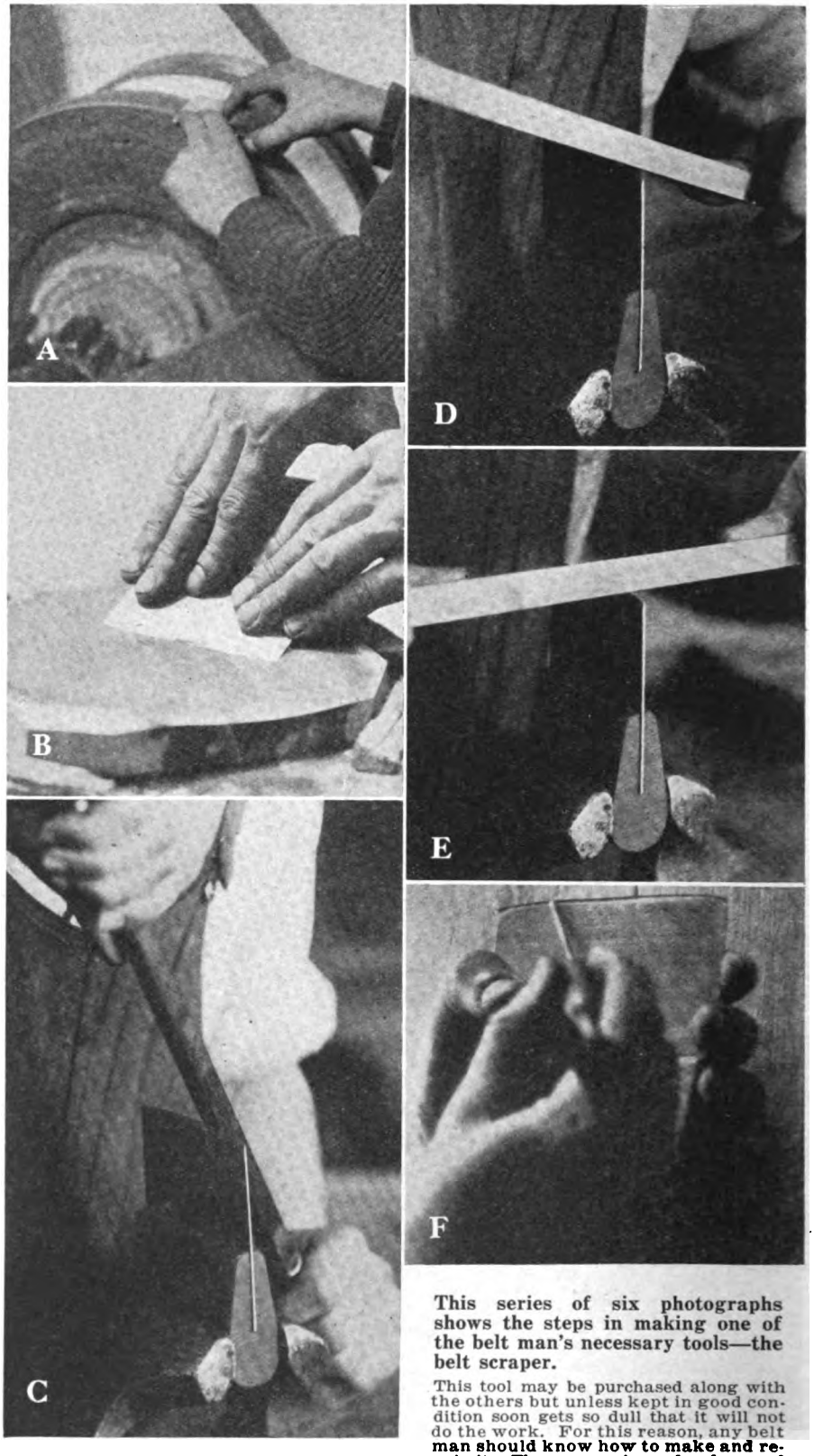
The easiest and best way to clean a leather belt is to roll it up and put it into a can of high-grade gasoline or naphtha or some of the various belt cleaning solutions. A low-grade gasoline will leave some grease in the belt. About 15 minutes is usually long enough to let the belt soak. If left too long the belt is likely to dry out more than is good for it and requires more oiling or "currying" to get it back into shape. Ordinarily a soaked belt does not require any scraping unless it is very dirty. Companies specializing in this work have several different solvents, as gasoline does not remove all impurities; it will not remove one common coating, rosin, which is frequently added to a belt to prevent slipping.

How Joints and Seams of Belts Are Repaired

When the feather edge of the seam opens, as it may if the belt travels with the tip of the lap joint on the outside of the belt pointing against the wind or rubs against any object, the first thing, before making repairs, is to remove the cause; that is, turn the belt or remove the object rubbing it. It does but little good to make the repairs without removing the cause, as they would only have to be repeated shortly. The first step is to pry the opening a little wider with a blunt tool such as a screw driver, clean it out with a scraper and reglue. It is best to tear the joint entirely apart and reglue but frequently it is not desired to stop any longer than necessary. Most belt glues must be applied hot. If the belt is waterproofed special cement must be used. The edges must then be pressed together and rubbed or hammered to remove air pockets. After the glue has been allowed to harden as prescribed by the manufacturer the belt is ready to be placed in service.

Generally it is not necessary to remove a belt from the pulley for this purpose unless it is desired to turn it end for end, or take it off for some other reason.

When it is necessary to rebuild a belt by taking off some of the old worn plys and putting on new, it is generally better to return the belt to the manufacturer or to companies which specialize in reclaiming and rebuilding belts as they are better supplied with belt presses and other necessary tools. However, many companies with a large amount of work do this successfully. The first step is to remove the damaged or worn ply by working the seam open with a blunt tool. The glue and torn parts should next be scraped away. The whole surface is then roughed up so that it will absorb the glue better, covered with glue, the new ply added and the belt put into the belt press. There is danger that the small presses which would be used in industrial plants, are not strong enough to force the air out

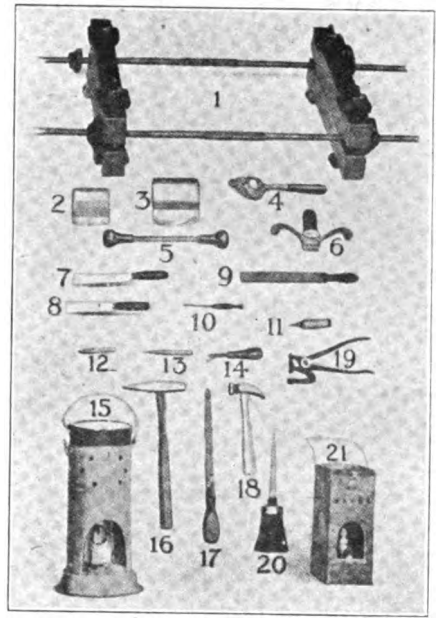


This series of six photographs shows the steps in making one of the belt man's necessary tools—the belt scraper.

This tool may be purchased along with the others but unless kept in good condition soon gets so dull that it will not do the work. For this reason, any belt man should know how to make and repair it. The scraper is made of a good grade of tempered steel similar to that used in saw blades and fitted into a handle as shown. The edge, however, must be turned at right angles to the blade so that it can be used to scrape to better advantage. The first step *A* shows the method of grinding a thin edge on the scraper on an ordinary grindstone. After this it is finished off, *B*, to a fine edge on a clearing stone. *C*, *D* and *E* show three successive steps in turning the edge. *F* shows the turned edge and the tool which is used to keep it in condition. These photographs are shown by courtesy of The Leather Belting Exchange, Philadelphia, Pa., an association of leather belt manufacturers.

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and make a tight joint. Also when these belts are sent to the manufacturer to be rebuilt the industrial belt man does not need to carry a supply of leather of different weights for repairs. This operation is probably one of the most difficult in belt reclamation. Here, as in other steps of reclaiming belts, it often pays to return the belts to a belt manufacturer or to a responsible concern engaged in rebuilding belts. Users, however, should not expect to get wide belts made from short, narrow strips. Also there is a shrinkage—often 30 to 50 per cent—due to metallic fasteners and oil or dirt imbedded in the leather. When a new ply is added the old leather should be used next to the pulley, as it is "broken in," and the new leather on the outside to give strength.



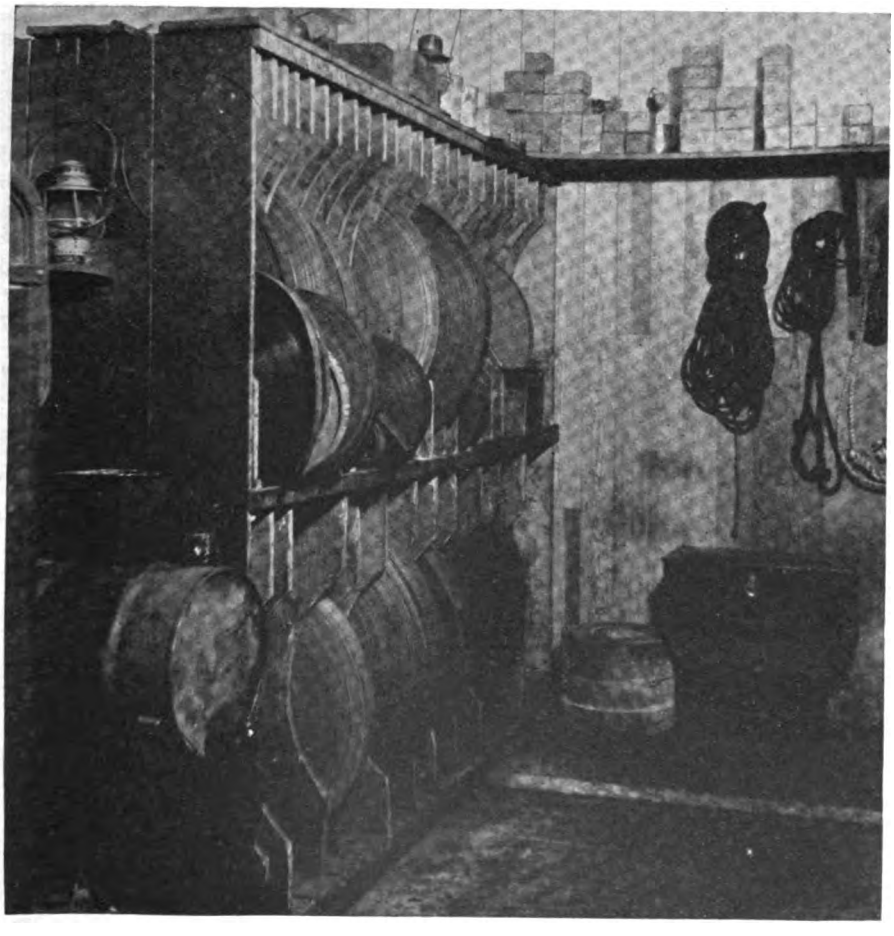
In belt work, as in any other line of maintenance work, a man needs good tools to do a good job.

These tools, many of which belt men already have, while others may be obtained from any manufacturer and most jobbers of belting, are almost necessary for good belt service. Those shown above, as listed by The Leather Belting Exchange, are: (1) Clamps and rods; (2) belt scraper; (3) slicker; (4) belt hoe; (5) belt shave; (6) spoke shave; (7) long skiver; (8) heel chop; (9) knife sharpener; (10) steel sharpener; (11) awl; (12) drive punch; (13) blind punch; (14) staple puller; (15) glue kettle; (16) ripping hammer; (17) screw driver; (18) pegging hammer; (19) hand punch; (20) 3½-in. best glue brush; (21) safety copper glue kettle.

Results of Good Belt Practices in One Industrial Works

The results of the practices in belt work at the Deering Works of the International Harvester Company, Chicago, indicate what may be accomplished through centralized supervision of all belts by competent, practical belt men. Here this work is under direct supervision of H. R. Slivinski, master mechanic. Each oiler looks after the belts on the machines he oils and tightens them up if necessary. When a belt gives way one of the two belt men repair it. The oiler, however, brings the belt to the belt room. This assures the return of the old belt, as another is not given out unless an old one is received. Also, if the belt shows abuse, the cause is discovered and remedied, if possible, before a new belt is put on. If the trouble cannot be removed easily or must be done by some other department, such as repairing leaks in the roof, the trouble is reported to the proper department which makes the repairs. If the belt shows satisfactory service, another of the same size is issued, otherwise, an investigation is made to see if the damage is the result of improper conditions or if a heavier belt is required. The old belts which are received are inspected, cleaned, repaired and reclaimed, if necessary, and stored for future issuance. New machines are installed with new belts but reclaimed belts are issued for replacement, if the proper size is available.

Mr. Slivinski favors good-grade leather belts for most power transmission purposes, and is confident that the better grades are the most economical, especially under severe service. For example, in one case, a large Sturtevant fan is driven by two 7-in. belts at 2,100 r.p.m. The pulleys are 10-in. in diameter with an 8-in. face. The belt speed here is 1¼ miles a minute. The rated speed of the fan is 1,400 r.p.m. This is an excessive overload on the belt and formerly when operated at 1,800 r.p.m., a belt was considered as giving excellent service if it lasted six weeks; most of the belts lasted less than a month. However, now a special heavy double-belt properly made with the backbone cut of the hide in the center of the belt is cemented



Belts stored in orderly arrangements such as this are easily accessible.

This photograph shows one corner of the belt storage space at the Deering plant of the International Harvester Company. Similar racks occupy the opposite side of the room. Each compartment is of a definite width for a certain size of belt and this width is marked at the top of the compartment. One of the first steps after the master mechanic's office took charge of the belt work was to issue all belts from a central storage. They also require that an old belt be returned before another is issued. Reclaimed belts are issued for all except new machines whenever one of the proper size is in stock. The steel cask in the left foreground contains a special belt oil used to keep belts in condition.

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endless. While this belt costs about twice as much as any other belt, it lasts a year or more, and so is much more economical in the long run.

Belts operated at high speed, as on wood-working and twine mill service, engines and motor belts, are cemented, endless leather belts. Other leather belts on machines are joined by metallic fasteners of one type or another. Preference, however, is given to a malleable hook with projections which are driven into the belt. If the proper size is used these projections do not extend through the belt, and as the hook is narrower than the belt, it does not offer any obstruction or point on the pulley side or on the edge. This hook is quickly applied—the ends of the belt are cut square, placed end to end on the hook projections which are then driven into the belt with a leather-faced hammer or a block of wood, which protects the points and does not clinch them. This hook may be pried off easily and used again if not clinched. On the outside it has the appearance of a plate and is curved to fit the pulley. Not a single rawhide lacing is used in the plant, because of the time required to lace and the weakening of the belt by the holes cut.

Flexible metallic lacings are used on Balata, rubber, and cotton-woven belts, which are installed under some conditions. For example, cotton-woven belts are used on tempering conveyors which run in an oil bath at 160 deg. F.; rubber and Balata belts are used in wet places, also some special belts are used.

Leather belts which have been returned to the belt room are not only cut down to a narrower width if damaged on the edge, but loose plies are recemented and sections rebuilt in the shop shown in the illustration at the head of this article. Additional belting, both old and new, is carried in a locked storeroom adjoining. The scarfing machine shown in an accompanying illustration originally was built for bench work but has been made portable by the addition of legs on wheels and a removable third wheel and handle which, when attached, lifts the machine and supports it on wheels so that it can be pulled anywhere. The belt press, operated by hand, and the pointing bench are shown in the background. Belt hooks, as well as other fasteners and supplies, are carried underneath the bench.



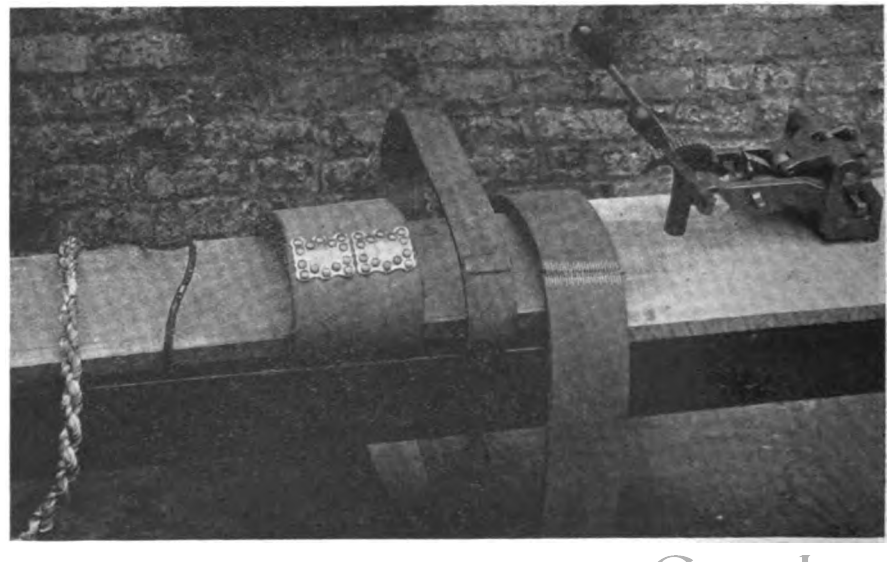
A collection of the belt tools used at the Deering Works.

This layout of belt tools is sufficient for the belt work carried on at this plant. Almost all of them are familiar to any shop mechanic. The others, those which are special to belt work, may be recognized by comparison with another illustration in this article which identifies each tool. The tool at the extreme left, however, is a leather-faced hammer which is used for driving the malleable fasteners without clinching the points.

Two large engine-drive belts, each 72-in. wide, 3-ply, which last about eight years, are cut down and used on smaller drives and in some cases are cut down and used over several times before they are thrown away. On these large belts it is occasionally necessary to open and remove air pockets between the plys. The joint is opened, the surface scraped and covered with cement, and the ply hammered to remove the air. This is done without removing the belt. Sections of belt which are cut out, because they cannot be used for transmission are cut into brake linings and used for other miscellaneous purposes. The scrap ends, trimmings, and short pieces, which cannot be used in rebuilding belts, are used in casehardening. In this way the belt is entirely used up, with but little waste.

This separate belt department was created in 1909 under the supervision of the master mechanic, and the first year saved several thousand dollars in the value of belt purchased, as compared with the amount for the previous year. A large proportion of this was due to a centralized stockroom and more close supervision over the issuance of new belts as well as in the reclamation and reuse of those belts which were removed. Records are not kept of each individual belt except in the case of the special belts, because of the large amount of clerical work involved, as there are approximately 17,000 belt drives in the Deering Works. Two men handle practically all the work involved. They are in close contact with all belt conditions and soon notice if anything begins to go wrong.

Another feature of this work which is closely related to the belt maintenance is the providing of special coverings for pulleys. Often



Examples of some of the methods of joining belts which are used at the Deering Works.

At the right is shown the machine used for making the first joint. This machine clinches a set of hooks into each end of the belt. The two ends are then hinged together by a rawhide pin. The next belt is fastened by the malleable fastener mentioned in the article. One or the other of these two fasteners are usually used on leather belts which are not made endless. The third belt shows the plate used to join rubber belts. Round belts have a special hook fastener as shown. The belt at the extreme left is a special twisted endless leather belt which is used on some special machines.

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when a belt slips slightly because it does not get sufficient grip on the pulley a special covering is added. This is made by adding three or four alternate coverings of a special pulley cement and wrapping with cheesecloth a little wider than the pulleys. The overlapping edge is trimmed off to the edge of the pulley. This gives a surface which grips the belt better and may be applied to either cast-iron, steel or wood pulleys. Also, by using narrow strips of cheesecloth in the center and covering with strips full width a pulley may be crowned or the crown increased.

While many smaller plants could not expect to make such a showing and could not afford to have two men devote all of their time to this work, they could at least have one man devote a part of his time to it. Practically every concern which has put the belt work under the direction of one competent man has found that this has made material savings in belt expense, without considering that real but intangible saving made through decreased shutdowns and increased production.

How to Make a Belt Scraper and Keep It in Proper Condition

One tool, the belt scraper, which belt workers use as much or more than any other is, because of its construction, a little more difficult to make and keep in shape. In some instructions on making belts endless issued by Louis W. Arny, secretary, The Leather Belting Exchange, Philadelphia, Pa., this tool is described and illustrated along with other tools for making leather belts endless and for doing industrial belt work.

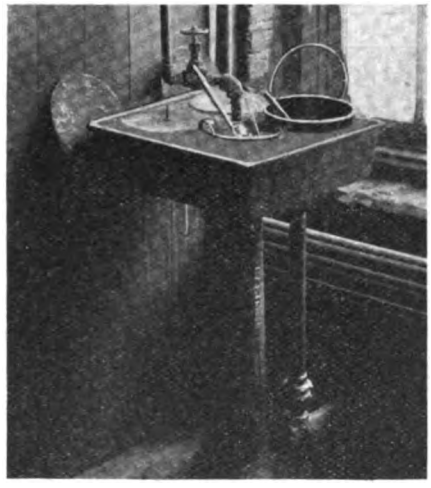
The weak point of every belt is the joining of the two ends. Not only is it the weak point, but also it is the point of most belt trouble. There are a multiplicity of devices for joining these ends, from the old lace-leather-sewn joint, to the endless variety of metal fastenings. Some of these are better than others. The remedy for all this annoyance lies in using only endless belts, that is, those in which the two ends of the belt are joined to make a continuous length. Some belts can be made endless on the pulleys satisfactorily, and some cannot. This paper applies only to leather belts which can be made endless on the pulleys satisfactorily.

The tools required for this are illustrated and listed in one of the illustrations on page 307. Some of these tools already are in the shop, and all of them, or any of them, may be obtained from any leather belting manufacturer. Only one of these, No. 2, is unusual to the ordinary mechanic—the turned edge scraper. This is a flat piece of good steel, about the thickness and quality of good saw steel, and is fitted in a handle as shown. The point about this tool is that it works with an edge which is turned at a right angle to the blade. This is accomplished by grinding a long edge, then rubbing this down to a fine edge on a "clearing stone," then with a smooth, hard steel tool, turning this edge so that its cutting edge is at right angles to the blade. With the tool firmly held in a vise, pressure is applied on one side, about at the angle shown. When the edge is smoothly and uniformly turned to the angle shown, the angle of the steel tool is changed, and the process repeated, and then is completed by using the steel tool at right angles to the blade. The steps in making this tool are shown in a group of illustrations on page 306 of this article through the courtesy of The Leather Belting Exchange.

A small steel tool, No. 10 in the illustration, which is round and slightly tapered with a smooth, hard point is used to keep this turned edge in good cutting condition, by rubbing its point on the under side of the turned edge, and its surface on the upper side. These turned edges are fairly durable, in working in leather, but when they are gone it is necessary to grind the tool again, and repeat the process of forming the edge.

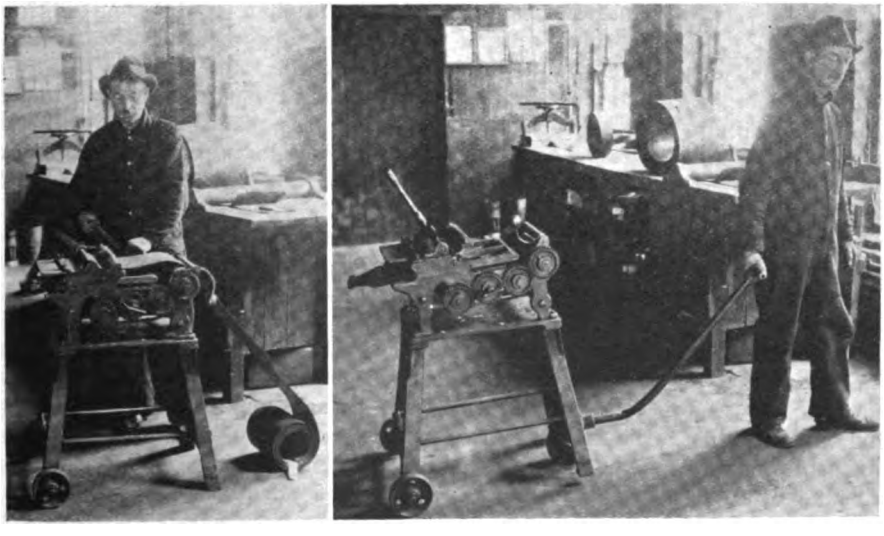
While working on the lap of the belt with this scraper, the belt is held by a special clamp as shown in the illustration on page 304, where the man at the right is using a scraper. The end of the belt is held down by an eccentric roller so that it acts like a cam and clamps the belt on a glass plate which protects the scraper. An advantage is that it can be quickly clamped or loosened.

The scraper is one of the most important tools in the belt maker's kit, because it saves much time in cutting laps, and because with its use it is easy *(Continued on page 324)*



This steam-heated glue pot supplies glue for cementing belts on work done in the belt room.

This glue pot is placed at the extreme end of the belt bench shown in one of the accompanying illustrations. Where belts are cemented out in the shop the portable glue pot, shown in the group of tools in an accompanying illustration, is used.



One of the handiest machines in the Deering belt shop.

This scarfing machine for putting a beveled edge on leather belts for making a lap joint when a belt is cemented endless, was originally built for bolting to a bench. For greater convenience, the Belt Repair Department mounted it on legs and wheels as shown. By the addition of a pivoted third wheel and handle it may be pulled to any part of the shop where a belt is being put on. Whenever possible it is used in the belt room.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, June, 1923

Wasting Ten Dollars to Save One

WHEN buying equipment the old question of price *vs.* quality almost always comes up. It is assumed that a higher price does not always mean better quality, but usually equipment prices, like those of other commodities, are based on what it is worth to the user and cannot for long be out of proportion to competitor's prices.

One argument which may be used to defend a larger expenditure for better equipment is that the purchase price does not represent an item which is used up and gone, but one which has an estimated useful life or service of say ten or more years. In that case, an extra $100 on the purchase price would mean only $10 a year. Perhaps the operation or processes dependent upon the reliability of continuous operation of the new equipment is such that any interruption of service would be expensive due to, for example, freezing of metal, clogging of a conveyor, or destroying of work or materials in process, or other similar conditions. In such a case isn't a greater assurance of reliability worth at least $10 a year? One failure might be many times as expensive. For that matter, every dollar saved may mean an expenditure of ten or more to make up for it.

Protection Against Things Seen and Unseen

RULES and regulations covering the installation of motors to eliminate as far as possible fire and accident hazards and possible injury to operators or unauthorized persons are now quite generally known and observed. Similar regulations that will protect the motor itself from injury arising from conditions or operations near it are not so generally observed.

Motors are found in pits where considerable moisture is present, in surroundings where the temperature is continuously high, where dust and dirt accumulate from operations on the machines they drive and various other conditions which penalize the performance of an electrical machine as a production unit and reduce its ability to carry the load for which it is rated by the manufacturer. Such conditions give many good motors a black eye in the estimate of the operator and the man responsible for its maintenance when, as a matter of fact, the trouble signs it shows point directly to a failure to exercise common sense when making the installation.

A couple of illustrations will be sufficient to bring out these points. In a certain plant sanitary requirements demand that the floors and machines shall be thoroughly washed each day. This operation is done by hot water from a hose in the hands of a clean-up man who has no knowledge of electrical machinery and hardly knows a motor from any other piece of machinery. His is a clean-up job and he plays his hose on the motor attached to the floor with the same violence as he does any other spot. In another plant where combustible material is present and fires are liable to start, which are checked by an overhead sprinkler system, the motors are protected by a metal roof type of shield. In this plant when a sprinkler head lets loose the motor is seldom injured by the spray of water.

In both cases open-type motors are used and attached to the floor but in one case a high and regular maintenance cost is created while in the other a less liable but possible maintenance cost is prevented. Both installations provide an opportunity to exercise plain ordinary horse-sense that will return a handsome saving in preventable waste of repair time and expense through simple schemes of protection that take little time to apply and cost only a small part of the expense of one complete repair job on an injured motor.

Protection is a term whose meaning can be effectively studied in every works from a wide variety of angles. We hope our readers who have done this will send to INDUSTRIAL ENGINEER the results of their findings and suggestions for conducting the investigations we now have under way that will cover practices or operating conditions on which they would like to get information from other readers.

What Is the Cost of a Repair Job?

CONSIDERABLE pride is taken in a repair shop when things are so organized that experienced men can do the work at a low cost per job. And in most shops a detailed record of costs is kept that shows labor and materials used and that troublesome item of overhead around which many argumentative wars have been and always will be waged. But there is a larger and more important element in repair costs that is regularly overlooked. It is the loss resulting from productive machinery standing idle during a repair job or until trouble can be located and the machines started again.

This is an item in repair costs that belongs in every cost record of a maintenance department for it will place responsibility for causes of repairs and give credit in keeping them down just where it belongs. If maintenance records show prevention of repairs through keeping this loss down, they are the finest recommendations for the ability of the men who are charged with the responsibility to find small troubles before they become large. If this loss is high it directs attention to two things. First, lack of adequate inspection and,

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second, abuse of machines by operators, or faulty installations.

High repair costs that can be traced to abuse of machines is an item that should be credited to the maintenance department, not charged to it, but unless repair records show the causes that create repairs and the losses attached thereto, a true minimum of repair costs can never be reached nor can a just credit be awarded to the man who knows how to prevent trouble as well as how to remedy it.

Do You Burn Clothes When They Are Soiled?

IN an article in this issue on the subject of belts, it is pointed out that approximately 65 per cent or more of the belts thrown away in industrial works have useful life in them which may be utilized. The operations required to reclaim old belts are not difficult. However, if it is not desired to do this in a plant, the old belts may be gathered together and shipped to companies which make a specialty of overhauling waste belting and putting it back into shape. The cost is much less than new leather belt and the belt when it is returned has a number of years of useful life still in it. Such a plan is worth trying and it is, at least, preferable to burning this leather belting in a furnace, and thereby getting nothing for it.

Of course it is not expected that small pieces and narrow widths, a foot or two long can be worked up economically into good belts. However, most belts that are discarded are much longer than this. Because a belt is full of oil and dirt is no sign that it is absolutely worthless. This can be cleaned by soaking in the proper solutions in much the same way that clothes are cleaned. Many companies who have made a practice of reclaiming their belts have found that they have made a saving of 15 per cent or more annually in their belt bill. We would not think of throwing away our clothes when soiled—why change our thinking when it comes to belts?

Use Little Ones to Catch the Big Ones

CLIPPING one-half of a turn, which amounts to about one-eighth of an inch, from the coil formed by twisting the vertical strands to the horizontal strands of woven wire fencing, might not appear to be worth doing, from the standpoint of saving wire. But many millions of such coils are made in a year and by clipping the ends in this way one large manufacturer of wire fencing saves $40,000 annually, without decreasing the strength or usefulness of the product. An idea that the platinum contacts used in telephone apparatus could be welded to the contact springs and thus save the shank of the platinum rivets then used, resulted in a saving of $200,000 or more a year. The platinum saved in each contact was much smaller than the head of a pin—but many millions of contacts are made in the course of a year.

Millions of dollars have been made or saved, by spectacular and revolutionary schemes, but no doubt just as many or more millions have been saved, in the aggregate, by paying close attention to the little things. After all, everything from the most complicated machine to life itself is made up of a lot of little things. On the surface, a fifteen-minute shutdown through interruption of power service merely gives the operators a little chance to discuss baseball or fishing with their neighbor workers. But wages and overhead go on just the same whether or not the wheels turn and one such interruption a week makes a surprising total of time and money lost in a year. The lack of an effective method of caring for and checking out material from the storeroom will almost inevitably result in many leaks and losses which, although they may be small individually, are collectively too large to be neglected. Instances such as this are to be found on every hand. All that one needs to find them is an investigative turn of mind and an unwillingness to believe that, because a thing has always been done a certain way, that way is necessarily the best way of doing it.

The author of the proverb: "Take care of the pennies and the dollars will take care of themselves," stated a proposition whose truth is not limited by the times or circumstances.

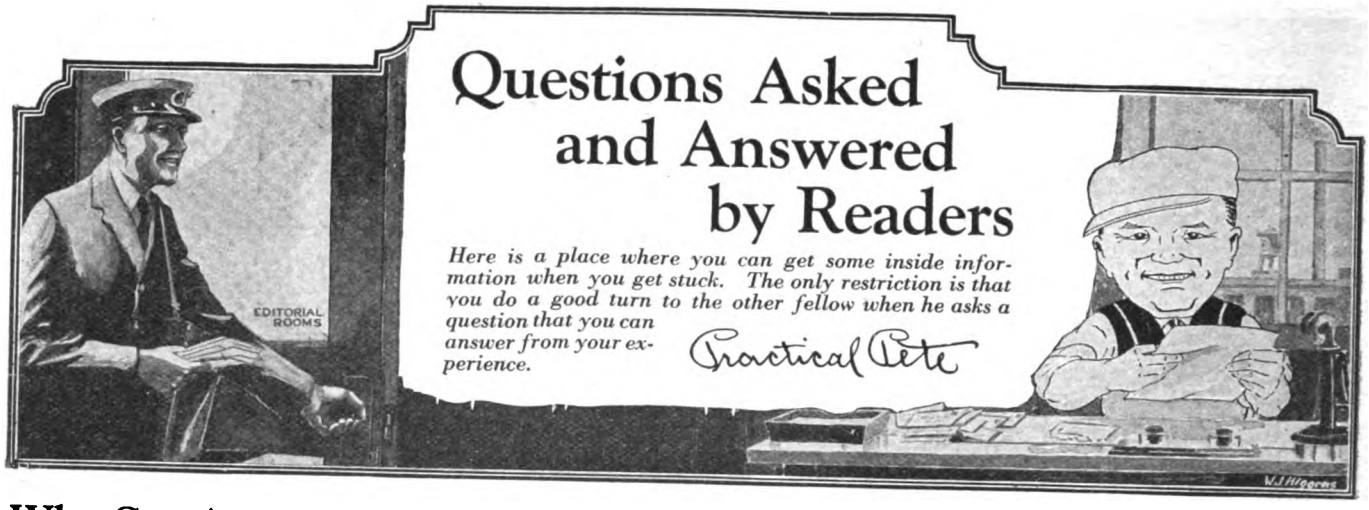
Service Around the Works

TIME is passing, and very rapidly, when department heads and foremen in industrial plants are paid for the hours of work the time records show. Production schedules are so closely laid out and so much depends upon the judgment of foremen and department heads that they are becoming specialists in the kind of work handled from a production standpoint. They are not only responsible for the quality of the work turned out as measured by certain plant standards but they are responsible for the effectiveness with which material and labor are used and their ability to keep the rate of production at a maximum under all ordinary conditions.

Among these men who are responsible for plant production is a relatively small group whose function and importance are growing day by day. This group is particularly responsible for continuity of power service and the mechanical handling of parts in process between machines and between departments. These men have a wide variety of titles but their responsibility is that of continuity of operation and maintenance and the elimination of breakdowns and shutdowns that can be anticipated.

The range of operation of these men, in the majority of cases, is as broad and as long as the plant itself and they are men who by training and experience are not only looked upon as experts in determining the condition of equipment in operation, but who are looked upon for a kind of judgment that compares with the judgment of a physician who diagnoses ailments of the human mechanism and administers preventive and curative treatment. The same measure of success that comes to a physician as a result of good judgment in diagnoses comes to the man responsible for operation and maintenance and when he combines initiative with an expert knowledge of maintenance methods he is paid—not for what he does day by day—but for what he knows and the results he can secure and he is creating for himself a position in the industry which is rapidly becoming recognized as an important division of production engineering.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Cleaning Gold, Silver and Nickel—I would like to have readers describe methods they are using to clean gold, silver, nickel, etc., by using a. c. current. Please give kinds of solutions used and a sketch of the outfit.
Elgin, Ill. L. W. B.

* * * *

Voltage between Transformer Neutral and Ground—I am looking for information which I am sure some of our readers can furnish. In a primary star connection with the neutral grounded, machine rating 4,000 volts, three-phase between phases, what voltage, if any, would there be to ground when three single-phase transformers of 2300-volt rating are star-connected to the primary side and the secondary side connected 440 volts delta? Also, what would it be if the secondaries were connected 440 volts star on the secondary side?
Elkhart, Ind. R. A. D.

* * * *

Requirements for Grounding Conduit—I would like to get some information on practice in grounding conduit. Has the section of the National Electrical Code, 1920 edition, paragraph F on page 27 of section 12 on wires covering class B outside work been changed? I refer to the ruling regarding short lengths of conduit for entrance wires. Formerly where only a few inches of conduit were used to make an entrance it was not required to ground this conduit, providing no conduit was used inside the building and the voltage was less than 150 volts. We are now required to ground all such conduit to a 1-in. gas pipe, which seems unreasonable and adds at least four or five dollars to the job. I would like to hear from other readers who have run into requirements of this kind.
Good Hope, Ill. V. W. M.

* * * *

Charging Ford Magneto Magnets—I should like to know how to charge the permanent magnets on a Ford magneto without removing them from the car. I have tried passing current through the armature coils, but had only two 6-volt storage batteries and these did not make the magnets strong enough to hold up very long.

Can some reader advise the voltage needed to produce the required current through the coils and the length of time the coils should carry current to produce the proper magnetism.
Moundsville, W. Va. J. W. M.

* * * *

Reducing the Speed of A. C. Motor—We have a 20-hp., 440-volt, 3-phase, 60-cycle, 1160 r p. m. motor having 36 coils. Each coil has ten turns of two No. 11 wires. The coils lay in slots 1 and 11 and are connected in series-star. We want to change this motor to operate at 860 r. p. m., 440 volts, 3-phase, 60-cycles, and still develop 20 hp. with seventy-two coils. The stator is 13 in. in diameter with seventy-two semi-closed slots ⅜ in. wide by 1 1/16 in. deep. The core width is 6 in. We have already wound this motor with seventy-two coils made of five turns of two No. 11 wires. The coils were placed in slots 1 and 8 and the group connected in series-star. On testing the motor we found that it ran 900 r. p. m. but took 44 amp. at 480 volts running idle, although it did not heat up much. Will some reader please tell us what size wire and how many turns per coil we should use?
Mansfield, Ohio. C. E. P.

* * * *

Reversal of Rotation of Watt-hour Meter—There are two questions I should like to ask the readers of INDUSTRIAL ENGINEER.

(1) We have an Ingersol-Rand compressor, driven by a Westinghouse synchronous motor. When this motor is started by an auto-starter the watt-hour meter will run in a forward direction, but as soon as the switch is thrown into the running position, the meter reverses its direction of rotation. By adjusting the field excitation up to 20 amp. the meter will run forward or in the proper direction, but as we have to run this motor with a field excitation of 35 amp. the meter will again reverse and run backward as soon as this current value is reached. This is a polyphase, watt-hour meter and the power factor never goes below 70 per cent. What causes this reversal?

(2) We are about to install four 300-hp., 2,200-volt, 3-phase, 60-cycle motors rated at 69 amp. per motor, or a total of 276 amp. What size polyphase watt-hour meter should be purchased in order to take care of the four motors?
Iron River, Mich. A. J. E.

Answers Received To Questions Asked

Expansion and Contraction of Steel Trolley Bar—What allowance must be made for expansion and contraction, due to changes in summer and winter temperatures, of a steel trolley bar 625 ft. long on an outside crane runway? This will be a (10 point carbon composition) rod 0.342 in. in diameter with supports 10 ft. apart. What is the best method of anchoring this rod to allow for this expansion?
Gary, Ind. A. L. G.

In the January issue of INDUSTRIAL ENGINEER, A. L. G. asks what allowance should be made for expansion and contraction in a steel bar used as a trolley wire for a crane. He did not state whether the bar was to be installed entirely indoors or out-of-doors, or whether it would be partly sheltered and partly exposed to the extremes of temperature; about the only data given was that it was to be 625 ft. in length.

The writer has had no experience with steel bars used in connection with cranes, but has had experience with several miles of such construction, under which trolley cars are operated. The expansion of 625 ft. of steel bar, even if installed out-of-doors, where the changes might amount to perhaps 100 deg. F. will not be very great and, if the construction is indoors, should be considerably less. The co-efficient of expansion of steel is only 0.00000633 per degree F., or 0.000633 for 100 deg. Then 625 ft. would expand 0.395625 ft. (say 0.4 ft.) for a 100 deg. change in temperature.

Since 0.4 ft. equals 4.8 in., if the bar were anchored at its middle point the expansion in each direction would be only 2.4 in. for the full 100 deg. of temperature change. However, the bar should be installed when the temperature is about midway between

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the two extremes and then its change in temperature would not exceed 50 deg. either way, or 1.2 in. change in length.

We install our trolley bar with slotted holes to permit of expansion and contraction, using a ⅜-in. bolt in the hanger to support the bar. The greatest length of the slot needed would then be ⅜ in. for the bolt and 2.4 in. for expansion, or about 2¾ in., placing the hangers so that the bolts would be in the center of the slots at the start, and thus giving 1.2 in. on each side of them for movement.

If the holes for the three hangers nearest to the center of the bar are drilled round, and of the proper size to just fit the bolts, so that there is no allowance for expansion or contraction, they should prove a strong enough anchor to prevent any movement of the bar at that point.

Westfield, N. J. G. H. McKELWAY.

* * * *

Winding a 1 to 1-Ratio Transformer—I want to wind a 1 to 1 transformer for 110 volts primary and 110 volts secondary and apply both primary and secondary wires at the same time. This would put the secondary winding in contact with the primary winding through the entire length with no other insulation between them, except that which is on the wire. What insulation would it require to withstand the stress for this kind of an arrangement? Would it require enamel and double cotton, enamel and single cotton or would double cotton be sufficient?

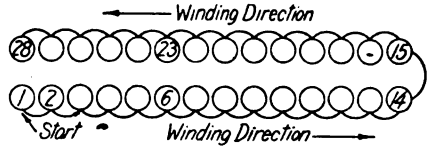
If I understand it correctly, when the primary pressure is a maximum the secondary pressure is zero, and when the secondary pressure is maximum, the primary is zero. Is this correct? If so, the emf. or current would not pass from one winding to the other, except when the secondary was grounded.

Logansport, Ind. L. E. G.

Double-cotton-covered wire will be satisfactory for winding it. Double cotton as applied to copper magnet wire punctures at 150 volts, approximately, but if the wire is reinforced with a good varnish this value will be increased to approximately 500-600 volts.

In this winding there is no danger of a flashover between adjacent primary and secondary wires, but the point to reinforce is between layers. The longer the coil the greater will be the difference of potential between the first turn of the first layer and the last turn of the second layer, as shown in the diagram.

Assume 2 volts per turn, then the voltage between conductors 1 and 2=2 volts, between 14 and 15=30—28=2 volts, between 1 and 28=56—2 or 54 volts, between 6 and 23=46



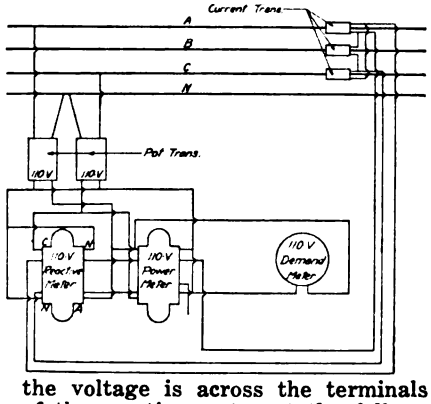
Transformer winding should be insulated between layers.

—12 or 34 volts. Hence the longer the coil the more turns per layer and the greater difference of potential between the start and finish of each layer. It is necessary to insulate between layers with 0.004 or 0.007 fishpaper. A. C. ROE.

Detroit, Mich.

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Voltage at Meter Terminals—The accompanying illustration shows the wiring for meters in our plant. I would like to have some reader check these connections and indicate what



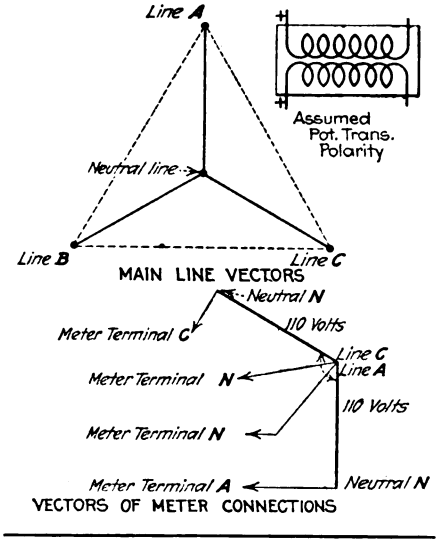
the voltage is across the terminals of the reactive meter at the following points: C to N, N to A and C to A.

Racine, Wis. T. G. L.

In answer to the question by T. G. L. on page 158 of the March issue of INDUSTRIAL ENGINEER, I submit the accompanying diagram which gives the vectors of the voltages across the meter terminals.

C. OTTO VON DANNENBERG.

New York, N. Y.



Vector diagram of voltages across terminals of reactive meter.

In answer to the question asked by T. G. L., in the March issue, with the connections as given, the voltages at the meter terminals will be C to N = 110 volts; N to A = 110 volts; C to A = 190.3 volts. This is because the common is connected to the neutral, thus making the voltages A-N and C-N actually only 60 deg. apart, or 110 times 1.73 = 190.3. This diagram is usually limited to the use of zero-center, indicating wattmeters to indicate reactive kva. and is not the correct one to use for the measurement of kva.-hrs. unless its limitations are clearly recognized. For example, on a circuit where the power factor may be sometimes leading and sometimes lagging, the meter may register first positive and then negative, making its total recording zero unless it is provided with a ratchet register. When the meter is calibrated as a straight watt-hour meter and then is used with this connection, its registration must be multiplied by the constant 0.866 to get true reactive kva.-hrs.

Summit, N. J. VICTOR H. TODD.

* * * *

Dielectric Constants for Insulation—In the February issue of INDUSTRIAL ENGINEER, J. B. Rakoske answered the question by L. E. G. and gave the dielectric constant for paper as 2. I would like to obtain a table of dielectric constants for all insulating materials used with motor windings. Perhaps this information has been compiled and some reader can tell me where to find it.

Brooklyn, N. Y. H. D. D.

Concerning the dielectric constants requested by H. D. D. in the April issue of INDUSTRIAL ENGINEER, I submit the following values:

Asphalt	2.7
Varnished cloth	3.5-5.5
Fiber	2.0
Fullerboard	7.5
Fullerboard, varnished	2.9
Mica	2.5-6.00
Micanite	2.5-6.00
Paraffin wax	1.9-2.3
Paper	1.5-2.0
Porcelain	4.0-6.0
Rubber	2.0-3.0
Rubber compounds	3.0-4.0
Shellac	2.75

These values are taken from Prof. Clarence V. Christie's excellent volume, "Electrical Engineering."

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

The following data may be of service to H. D. D. whose request for a table of dielectric constants appeared in the April issue of INDUSTRIAL ENGINEER. The specific inductive capacity of various dielectrics vary with the shape, size, temperature, and so on, and by the manner in which the stress is ap-

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plied. The values given below are safe averages for ordinary conditions:

Air	1.00
Paraffined paper	2.00
Glass, common	3.00
Hard rubber	2.50
Gelatine	4.00
Kerosene	2.00
Mica	6.00
Bakelized paper	5.00
Glass, light flint	6.50
Celluloid	4.50
Porcelain	4.25

Plant Engineer, S. G. ST. CLAIR.
Kilbourne & Jacobs Mfg. Co.
Columbus, O.

* * * *

In answer to the question by H. D. D. in the April issue, some time ago when making some radio experiments I found a table of dielectric constants covering some of the materials used as insulation. The dielectric constant $=K=C^n \div C^{air}$

Substance	Value of K
Mica	4-10
Hard rubber	2- 4
Paraffine	2- 3
Paper, dry	1.5- 3.0
Paper treated as used in cables	2.5- 4.0
Shellac	3- 3.7
Celluloid	7-10

I trust that the above data may be of some service to H. D. D.

Boston, Mass. A. L. MORLEY.

* * * *

Changing Connections of Motor Fields—I would like to see a diagram showing exactly how to change a 220-volt d. c. motor for operation on 110 volts. The present speed is 900 r.p.m. and the rating of the motor is 60 hp. What will be the horsepower at 110 volts and the speed? Will it be necessary to change the armature winding? If so, please indicate the changes necessary. The motor has six field coils.

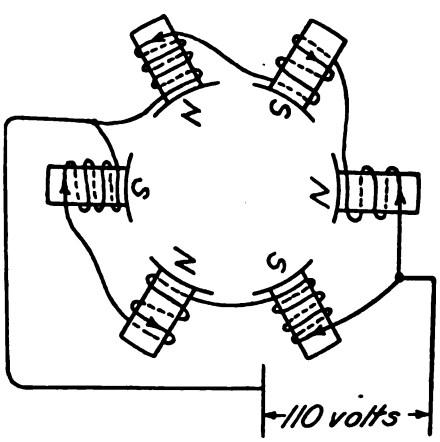
Emaus, Pa. J. A. K.

In reply to the question by J. A. K. in the April issue, the shunt field of the 220-volt, 60-hp. motor may be reconnected for 110 volts by dividing the coils into two series circuits and connecting these in parallel. The motor may then be operated on 110 volts with the armature winding remaining the same, but the speed will be reduced from 900 to 450 r.p.m. and the power to 30 hp. The speed may be increased to about normal by inserting resistance in the shunt field circuit, but the horse-power will not be changed. If the motor must develop 60 hp. at 900 r.p.m. on 110 volts, it will be necessary to rewind or reconnect the armature so that it will have one-half the number of conductors in series per path through the winding and two times the number of pairs, or two times the current-carrying capacity per pair. Before making this change, the brush rigging and commutator should be checked to be sure that the armature current, which will now be double its former value, can be commutated. W. E. PAULSEN.

Des Moines, Iowa.

* * * *

In reply to the question by J. A. K. in the April issue of INDUSTRIAL ENGINEER, I would say that after changing the winding on his motor the horsepower and speed will be practically the same. The field coils should be connected in series-parallel as shown in the diagram. The armature will have to be rewound, using half the present number of turns and twice the present size of wire. Also, he will have to make sure that the commutator and brushes will carry twice the original current without over-heating.



Field coils of 220-volt motor connected series-parallel for 110 volts.

The current density of carbon brushes should be from 40 to 50 amp. per sq. in. and for copper brushes 150 to 175 amp. per sq. in.

Americus, Ga. B. BELCHER.

* * * *

In answer to J. A. K.'s question in the April issue, regarding changing a 220-volt d. c. motor to operate at 110 volts, if it is desired to obtain the full horsepower of the motor rewinding of the armature and changing of the field connections would be required. If the fields are now connected in series, reconnecting them in multiple-series without making any changes in the armature will give you a little over half the rated horsepower, with practically the same speed as before. C. M. FLUKE.

Manager,
Raystown Water Power Co.,
Roaring Springs, Pa.

* * * *

Trouble with Type C Mazda Lamps—During the last few months I have been having trouble with 100- and 200-watt, type C, Mazda lamps burning out. In about 50 per cent of the cases when the 200-watt lamp burns out, it short circuits where the lead wires go through the inner glass tube down to the filament. I have had four cases where the outside globe has been bursted. When this trouble started, I thought it was due to vibration but have since found that this is not the cause as lamps attached to heavy I-beams show the same trouble. This trouble does not occur quite as often with the 100-watt lamps. In both cases when this trouble comes up the fuses in the circuit are blown. Our operating voltage is 230 d. c. and we use 240-volt lamps. Has anyone experienced this trouble and found a remedy?

New Orleans, La. P. B. A.

I should like to reply to the question by P. B. A. on page 210 of the April issue of INDUSTRIAL ENGINEER regarding trouble with Mazda C lamps. Generally speaking, there is always more trouble with incandescent lamps on 220-volt circuits than on 110-volt circuits. There are two general reasons for this: (1) Difficulty in handling 220 volts and above in incandescent lamps; (2) a large percentage of 220-volt circuits are direct-current circuits.

The usual advantages in electrical equipment resulting from higher voltages do not obtain in the case of incandescent lamps. The carrying of high-voltages through the base and the glass stem into the lamp and the mounting of sufficient filament in the lamp present difficulties which persistent effort on the part of the lamp manufacturers has never been able entirely to overcome. This is borne out by the fact that, wattage for wattage, the 220-volt line is more expensive than the 110-volt line and also less efficient. This condition is made worse by the fact that a large proportion of 220-volt circuits are direct-current circuits. Even though a lamp may fail in a perfectly normal way by filament burnout after crystallization, the abrupt cutting off of current frequently produces an arc which persists, due to the unidirectional flow of direct current, until enough tungsten has been volatilized and electrical energy dissipated to create considerable heat.

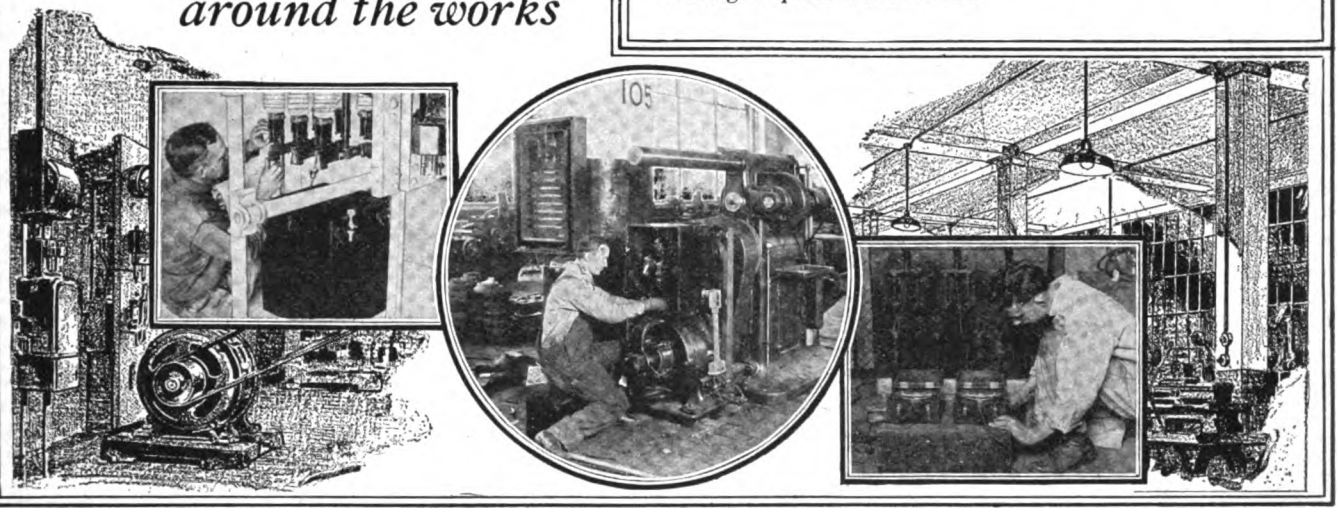
The proper fusing of 220-volt circuits serving incandescent lamp loads, especially in the case of direct current, will do very much to protect the lamps in such cases as are mentioned in the inquiry. The elimination of 220-volt circuits for lamp loads, just as far as possible, has become general practice in new installations. CHESTER L. DOWS.

Engineering Department,
National Lamp Works of G. E. Co.,
Nela Park, Cleveland, Ohio.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



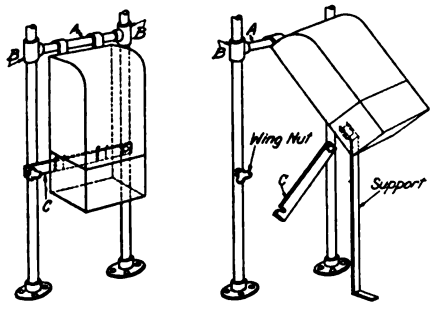
One Method of Mounting Compensator to Make Repairs Easier

THE ACCOMPANYING illustration shows how a Canadian General Electric compensator can be mounted so that repairing of contacts and so on will be much easier. As will be seen, the compensator is hung on a pipe, *A*, that is screwed fairly loosely into the two tees, *B*, in the upright pipe support. The compensator is held rigid at the bottom by a flat iron bar, *C*, which is pivoted on one leg of the supporting frame and secured under a wing nut on the other leg.

For inspection or when it is necessary to do any work on the compensator the bar, *C*, is loosened by unscrewing the wing nut and allowed to drop down from under the hook bars on the back of the compensator. The compensator is then swung upward from the bottom and a heavy stick, piece of pipe, or other suitable support placed underneath it to hold it up out of the way while work is being done.

J. H. SAUVE.

Timiskaning, Quebec, Canada.



The compensator is supported at the top on a cross pipe in an upright frame and held rigid at the bottom by an iron strap which can be removed to allow the compensator to be swung upward for inspection or to facilitate repairs.

Magnet Facilitates Recovery of Small Iron Parts From Plating Tank

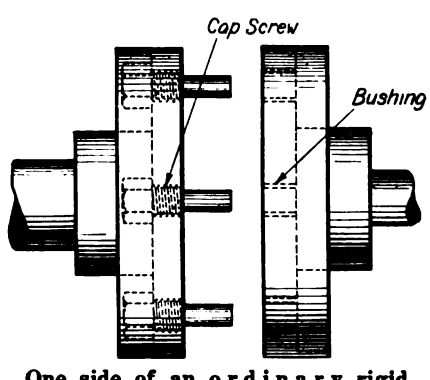
IN THE electroplating department where small iron castings are finished, often small parts accidentally fall to the bottom of the plating tank and must be recovered at once in order to complete a certain lot. Inasmuch as these tanks are approximately 4 ft. deep, it is sometimes difficult to get the parts out. An easy way of doing this, however, is to use an electromagnet wound on the end of a long rod and energized by the 6-volt current from the plating tank busbars. In making a magnet for this purpose, wind about 2 lb. of No. 16 bell wire, 1 lb. on each side, of a horseshoe-shaped iron bar 6 in. long. After the coils are wound they should be made waterproof by giving them two or three coats of P. & B. motor varnish. Such a magnet will lift a large number of small parts. A rod long enough to reach to the bottom of the tank, so that the operator will not get his hands into the solution, should be welded to the magnet. If the two leads from the magnet are tipped with spring clips or clamps they can be readily attached to the busbars of any tank and thus be used when and where needed.

H. S. RICH.

East Berlin, Conn.

How to Make an Inexpensive Flexible Coupling for a Special Job

A FLEXIBLE coupling for a centrifugal pump drive was recently made by the writer from an ordinary rigid coupling. This device, which possesses several desirable features, is giving excellent service, and might be adapted to a variety of drives where a coupling of slight flexibility is desirable. For making this an ordinary rigid coupling of the proper size for the drive was selected and the hubs bored to fit the shafts. As will be seen from the accompanying illustration, the four bolts were then removed and the bolt holes on one side provided with female threads. The bolt holes on the other side were bored to a slightly larger size and brass bushings shrunk into them. Four cap screws were then made up with the threaded portion long enough to fit the threaded half of



One side of an ordinary rigid coupling is fitted with cap screws which work loosely in brass bushings in the other side of the coupling.

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the coupling and provided with an extension turned down to a slightly smaller diameter than the holes in the brass bushing in the other half of the coupling, into which they fit loosely and thus give the desired amount of flexibility.

This coupling possesses the advantage that it does not interfere with the easy removal of the motor or driven machine either by sliding or lifting out after the four cap screws are removed, and also that the only wearing parts, the brass bushings, are easily renewed when they become worn down more than is desirable. FREDERICK KRUG.

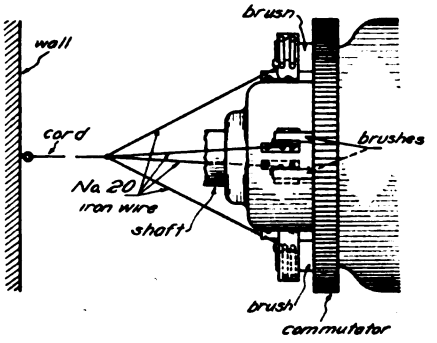
Comerio Falls,
Bayamon, Porto Rico.

To Maintain Service Brushes on Repulsion-Induction Motor Shifted by Hand

SOME time ago a 2-hp., single-phase repulsion-induction type motor failed at a critical time through the breaking of the brush-shifting ring on the spring barrel. This was due to unsymmetrical wear of the shoulder on the spring barrel, causing severe binding and jamming of the ring. Inasmuch as this motor could not be spared from service and no other motor was available, it was decided to remove the shifting ring entirely, since its purpose was merely to remove the tension of the brushes and thus reduce wear on the commutator.

The motor operated satisfactorily, but the noise due to the permanent contact of the brushes on the commutator was unbearable, as the motor was in the basement of a fine residence. Therefore, some way had to be devised for removing the brush tension. Accordingly, four pieces of No. 20 iron wire were attached, one to the lower outer stud of each of the four parallel motion fingers, as shown in the accompanying illustration. The other ends of the wires were tied to a stout cord and fastened to a screw eye in a nearby wall. Inasmuch as this motor was always under manual control, this scheme worked out all right. When starting, the brushes were allowed to make contact with the commutator. After the motor came up to speed and the commutator was short-circuited by the short-circuiting weight, the brushes were pulled away slightly by means of the cord which was then made fast.

No harm could result from this arrangement because if by chance the switch were thrown in while the brushes were out of contact with the commutator, and the short-circuiting weight was out of contact, no current would flow as the rotor would be open-circuited.



The brushes were shifted by small wires attached to each of the parallel motion fingers and tied to a cord which passes through a screw eye fastened to the wall.

HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

Four Methods of Turning Conduit in an Emergency Without a Pipe Wrench

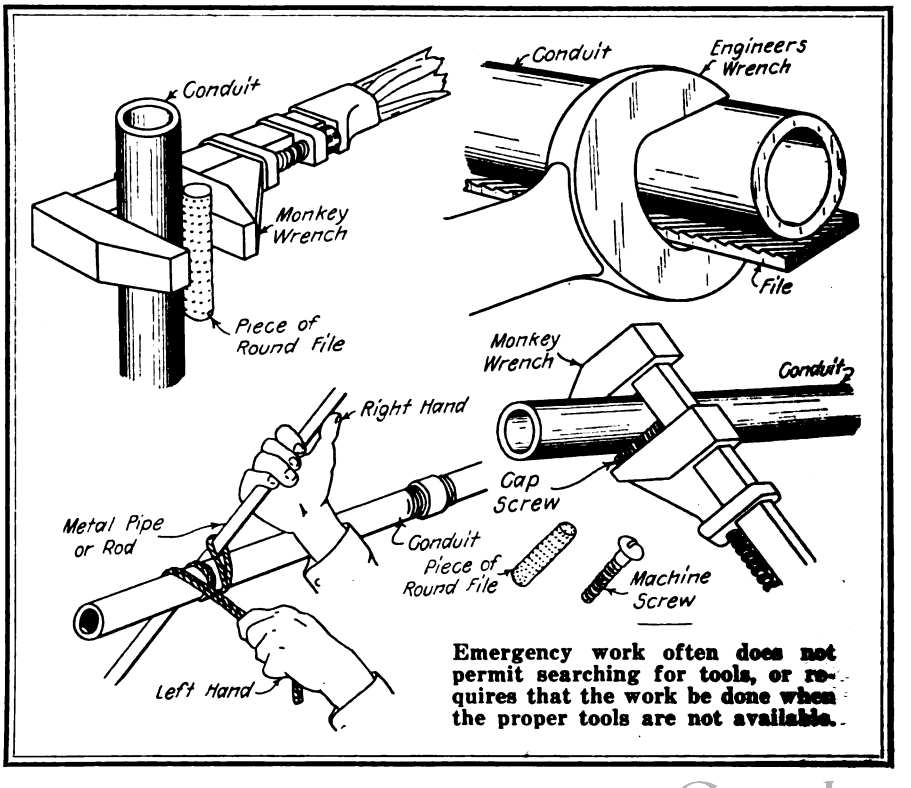
WHILE good workmen want good tools, and the proper tools to do a good job, it is also a sign of a good workman if he still can do a presentable job in an emergency with makeshift tools. For example, while none of the four methods of screwing or turning conduit or small piping shown in the accompanying sketch would be recommended for regular practice, still, for emergency work any of them might serve a good turn. Doubtless numerous other ways would occur to many of the readers for doing similar work, should occasion require. One advantage, however, of these four methods is that the necessary tools and the attachments can be found in almost any location even though a pipe wrench is not available. G. F. H.

Chicago, Ill.

Using a Float on High and Low-Water Alarm for Water Tank

AN ALARM which signals in case of either high or low water is in use on a tank in a St. Louis factory. A red light indicates that the water is at the lowest permissible level and the pump must be started. A green light shows that the high level has been reached. As shown in the accompanying sketch, a wooden drum is mounted on a shaft made of ¾ in. brass tubing and has four turns of cotton cord to the ends of which are attached a copper float and an iron weight. One end of the drum shaft is threaded through a brass sleeve set in one of the supports; the other end is smooth, and passes through a brass sleeve set in the opposite support.

When the water in the tank is at normal stage, the drum is midway



Emergency work often does not permit searching for tools, or requires that the work be done when the proper tools are not available.

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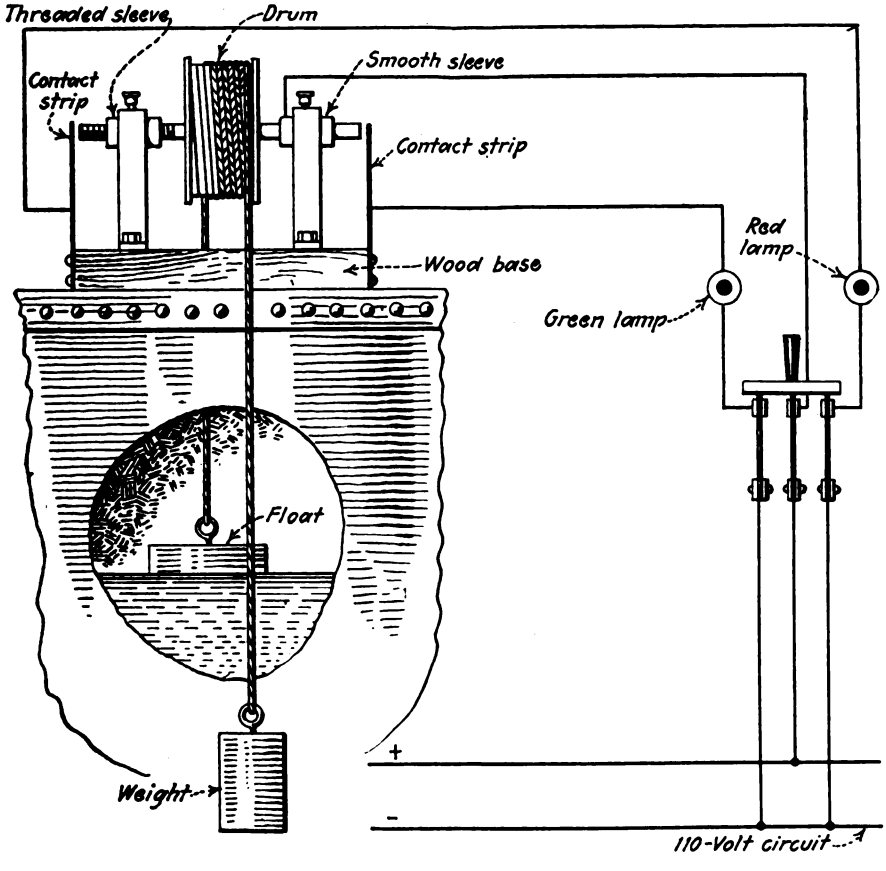
between the supports so that the ends of the shaft stand away from a pair of copper contact strips which project upward from the ends of the varnished hardwood base on which the drum supports are mounted. If the level falls, the drum and shaft rotate as the float lowers. This causes the shaft to advance toward the left-hand contact strip and closes the circuit when the lowest permissible stage is reached. This lights a red lamp which is located in a conspicuous place in the engine room. When the level rises, the drum and shaft rotate in the opposite direction, due to the falling of the weight. When the overflow stage is reached the smooth end of the shaft makes contact with the right-hand strip and closes the circuit through a green lamp which is mounted alongside the red one. The wiring circuit is shown in the accompanying sketch.

The pitch of the thread on the shaft is 0.1 in., the depth from the high to the low stage of water is 62 in. and the diameter of the drum is 10 in. Hence, while the water is rising from the extreme low level to the overflow level, the drum makes approximately two turns and the shaft travels endwise 0.2 in. in shifting from one contact to the other.

A. J. DIXON.

St. Louis, Mo.

Through this float and weight arrangement a red or green signal lamp lights when the water reaches either the low or high limits.



Trouble Caused by Heating of Ferrule-Type Fuses in Single Finger Clips

ON SEVERAL occasions we have had mysterious cases of fuses blowing and in some instances the fiber part of the fuse was carbonized near the end. In two cases we narrowly escaped having a fire; this was prevented only by the fireproof cabinet in which the cutouts were placed. In every case the trouble was found to be incident to the use of inclosed fuses having ferrule contact in single-finger clips.

Careful investigation showed the fuses to be passing current well under their rating. When the fuses were first installed all contacts on both ferrules and clips were thoroughly cleaned, but after the lapse of a week or so the ferrules and clips would commence to tarnish and would get very hot. After this action once started it would grow steadily worse until the fiber tube carbonized and the eventual blowing of the fuses opened the circuits.

The ferrules were found to be circular and the cutout clips happened to be so mounted that they could line up when the fuses were inserted. Apparently the clips had the proper curvature to give the full intended area of contact, but actually such full area of contact is never realized in practice. This was proved in every instance so far tried by simply revolving the fuse a few times, which would cause a scratch, and seldom more than one, to appear on the ferrules, thus showing plainly the actual extent of the area of contact, which was always surprisingly small. The cause of the heating was thus plainly due to insufficient contact area. I improved the contact in one instance by sawing a vertical slot in a clip, thus changing it from the single-finger type to the two-finger type and giving additional points of contact; this reduced the heating considerably, but not quite enough. It is evident that multiple-finger clips should always be used, inasmuch as it is practically impossible to get anywhere near the intended area of contact with the solid or single-finger clip. Otherwise, the ferrules should be made longer or the rating much reduced, or both.

As the result of my experience I can say that I do not care for the ferrule-type fuse, even though it is used with multiple-finger clips, except in cases where the full rating of the fuse is never approached for more than a few minutes at a time. Even then, oxidation will gradually occur and when it is once started such action is rapidly cumulative.

Again, if by chance a fairly good area of contact is realized when the clips are new, it soon diminishes after several insertions of fuses due to the change in the curvature of the clips resulting from springing them apart enough to allow the fuse to enter. Also, after being heated several times the clips lose their temper and the contacts become worse.

At best, I consider such fuses poor devices and a more or less unnecessary fire hazard, and suggest that their use be abandoned, except for the small sizes, 10 amp. and under, and the use of the knife-blade contact type adopted in its place. Even with the knife-blade type of fuse, the full area of contact is never obtained, although it is very closely approximated in the type using the U loop clip as in knife switch construction.

HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

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Motor Overloaded by Over-Size Impeller in Pump

A TWO-HORSEPOWER, 230-volt d. c. motor, direct-connected to a centrifugal pump had some armature coils burnt out and its journal boxes worn so much that the armature was striking the pole faces. On examining this armature it was found that it was in very bad shape, with the commutator almost completely worn out. The cheapest and quickest way of putting the motor in service again was to put in a new armature and new journal boxes.

After this was done the motor was re-assembled and connected up to the pump. After running about three hours the motor heated up considerably; so a test was made to determine the motor input. The motor nameplate called for 2 hp., 230 volts, 8.1 amp., 1700 r.p.m. A test gave the following results: volts 205, amp. 14, equals 3.86 hp. input. This means that this motor was developing 3.1 brake-hp.

This motor had been in service for over two years and further investigation showed that it had given entire satisfaction for the first 1½ years. At this time a new impeller was put in the centrifugal pump as the old impeller had a badly worn shaft. We were told that ever since then the motor had given trouble in the way of requiring frequent renewal of brushes, and so on. The result of the test showed that this is exactly what would be expected. We also found out that since the new impeller had been installed the motor had been pumping more brine than originally. The results of the investigation thus apparently showed a case of an oversized impeller.

The horsepower required varies as the cube of the velocity. Then $3.1 \div 2 = Vo \div Vn$, where Vo equals the old velocity and Vn equals the new velocity. From this equation it is seen that Vn equals 0.88 Vo.

This means that the diameter of the impeller was too large and, in the case of a shrouded impeller, should be reduced 12 per cent. With an unshrouded impeller, as was the one in question, this value would have to be increased from 3 to 5 per cent. Accordingly the diameter of the impeller was reduced 17.5 per cent. The original diameter was 8 in.; so it was reduced to 6.6 in. When the pump was re-assembled and tested the following results were obtained by test: volts 232, amp. 8, r.p.m. 1610.

The flow of brine obtained after the impeller was turned down was satisfactory, while the horsepower required to do the work did not overtax the motor.

EUSTACE C. SOARES.
Electrical Engineer,
Ophuls & Hill, Inc.,
New York City.

An Easily Applied Graphic Method of Determining Power Factor

THE ACCOMPANYING chart and scale are used to determine the power factor in an industrial plant where the voltage is constant. The system is 3 phase, 480 volts, 60 cycles. The chart can be used for any conditions of balanced load but the scale must be changed to suit the voltage.

In the first column of the scale there is given the apparent kva. In the second column of the scale are the significant figures for corresponding amperes. The scale is based on the equation, kva. = 1.73 × E × I: hence I per kva. is 1.2041, or kva. per ampere is 0.83, for 480 volts, 3 phase.

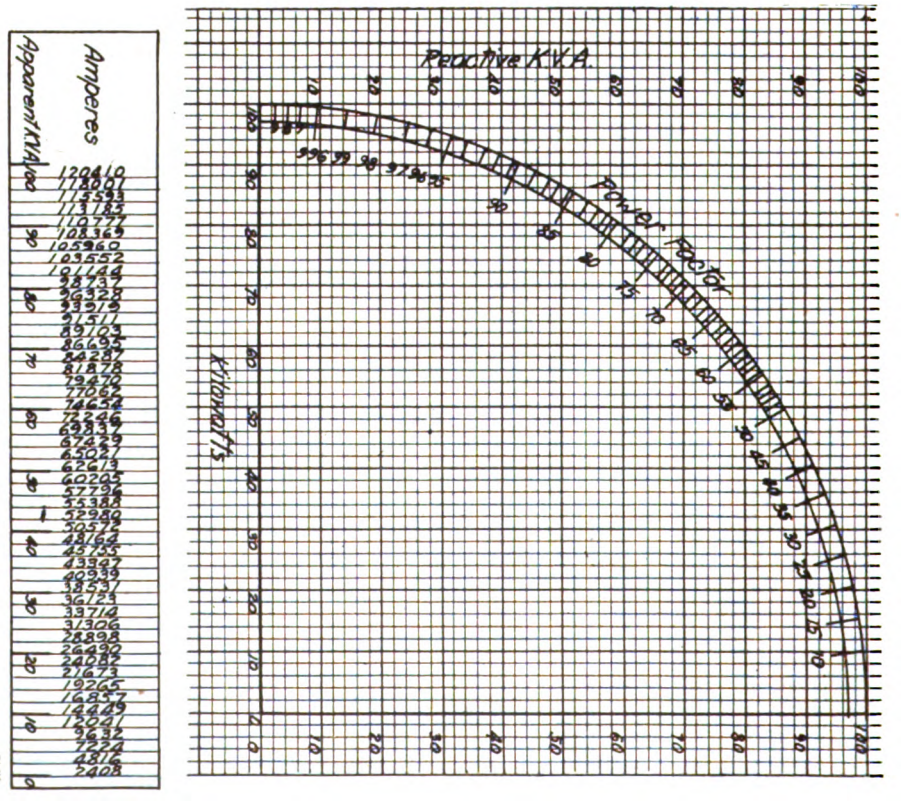
The power factor scale on the chart is laid out with a protractor and reference to a table of cosines, or directly from the scale, as 1,000 kva. on the scale coincides with 900 kw. at a power factor of 90. The chart and scale show the apparent kva., amperes, reactive kva., kw., and power factor all at one setting of the scale. To use this chart, proceed as follows:

Assume that the amperes and kw. are known, as for example, 481 amp. and 360 kw. On the scale opposite 481 amp. we find 400 apparent kva. Now place the zero point of the scale on the zero point of the chart so that 400 kva. cuts the horizontal line corresponding to 360 kw. Reading along the left side of the scale, it will be seen that this setting of the scale gives a power factor of 90. Reading upward along the vertical line from the intersection of the scale and the horizontal line representing 360 kw., it will be seen that the reactive kva. equals 175. The scale and chart can, of course, be used in making calculations of power factor correction when this is accomplished by the use of synchronous motors or otherwise.

Everett, Wash. W. L. STEVENS.

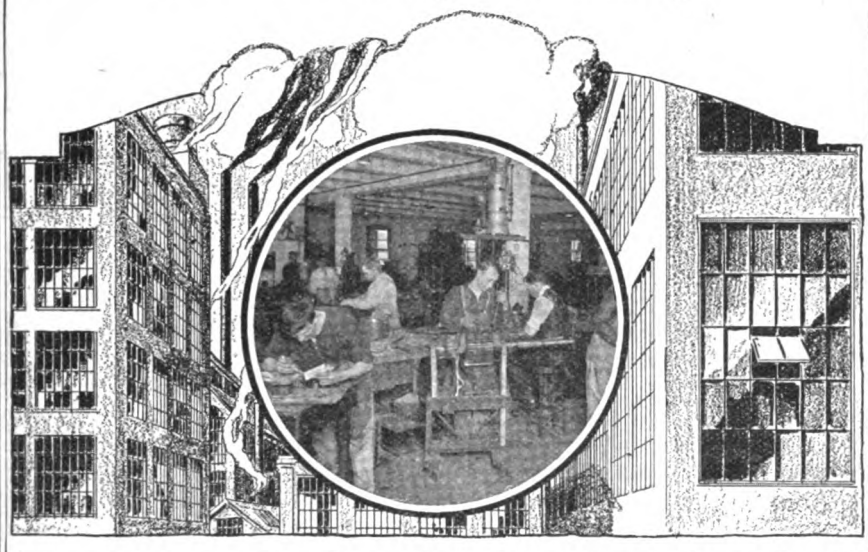
Power factor can be read directly from this chart and scale.

The load in amperes is found in the second (right hand) column of the scale. The corresponding apparent kva. is then found on the same line in the first column. The zero point of the scale is then placed on the zero point of the chart so that the line of the scale representing the apparent kva. cuts the horizontal line of the chart corresponding to the load in kw. The power factor is then read off on the power factor curve, from the left side of the scale. The reactive kva. are found by reading up along the vertical line from the point of intersection of the line of the scale representing the apparent kva. and the line on the chart representing the kw. load.



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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Iron Ring Useful for Heating Commutator Before Soldering

A PIECE of iron measuring about 2 in. by 2 in. in cross-section and bent in form of a half circle, with the inner radius equal to that of the commutator, has been found very useful by the writer for preheating commutators where a large number of armatures of the same size are constantly under repair. The ring is heated to a red heat and placed on the commutator for a few minutes to warm it up thoroughly. The ring is then removed and the final removal or soldering of leads is done with a soldering iron. It has been found that this speeds up the work considerably, and if care is exercised no damage will be done to the commutator. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

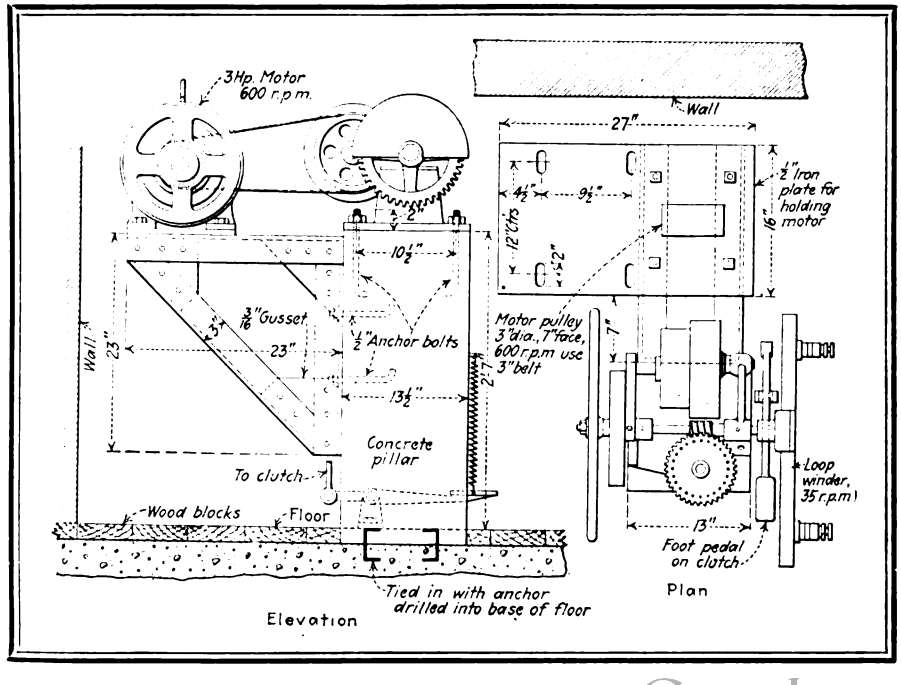
Motor Drive for Coil Winders Saves Overhead Belting

BY MOUNTING the driving motor on the same concrete pillar with a coil-winding machine an overhead belt is eliminated in the repair shop which the writer supervises. The illustration shows the Segur lathe-head coil-winding machine mounted on the concrete pillar. A steel bracket frame was constructed of angles and plates for supporting the motor. This bracket is fastened to the concrete pillar by means of anchor bolts cast in the concrete. The motor is belted to the stepped pulley of the winder and the motor pulley is as wide as the stepped pulley. Belt adjustment is made by means of slots cut in the plate supporting the motor, although a standard adjustable motor base could be used. This drive is not equipped with an idler, as the comparatively small amount of belt pull does not require an idler to prevent slipping.

The motor used is a 3-hp. four-pole, 25-cycle, 440-volt squirrel-cage machine which was reconnected for six poles to reduce the speed from 750 to 500 r.p.m. This gives the proper speed on the winder without using a counter shaft. A welded sheet-metal guard was used to cover the driving mechanism.

Two such winding machines are employed to handle the repairs for about 1200 motors. The cost of the two direct-drive mechanisms amounted to about the cost of the overhead drive with a single motor, and in two years' service has proved far more desirable than the overhead drive, which had been employed.

Electrical Engineer, J. E. HOUSLEY.
Aluminum Ore Company,
East St. Louis, Ill.



Coil winder and its individual motor mounted on concrete pillar.

Reversing Position of Rotor Caused Motor to Heat

A RATHER unusual condition was disclosed when the writer was recently called upon to locate the cause of heating in a new 10-hp., single-phase, 60-cycle, 220-volt, commutator-type motor. An examination showed that the motor had been taken apart and assembled in such a manner that less than half of the rotor core was running in the stator core. That this was possible is due to the fact that the stator core and rotor core are not in the center of the stator frame but considerably nearer the pulley end. In installing the motor the wiring had been laid out for the shortest length of conduit. The motor was then placed so that the leads were convenient to the conduit, but this made the pulley come on the wrong end of the mo-

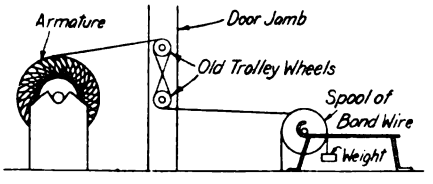
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tor so the rotor was taken out and put in from the opposite end. With the rotor in this position the magnetic field tended to pull the rotor into the center of the stator, which produced an abnormal end pressure on the front bearing, thereby causing it to heat and grip the shaft. After the bearing had been forced off the shaft and scraped smooth, the motor was properly re-assembled and turned around. After this was done it carried its load quietly and without heating. A. HERVEY.

New York City.

Easy Method of Putting Tension on Wire When Banding Large Armatures

UNLESS the work can be done in a lathe, banding armatures is at best a rather laborious and time-consuming operation. Many different schemes are used by repair men for obtaining the desired tension on the band wire, but a method which I have found very satisfactory may be of interest to the readers of INDUSTRIAL ENGINEER. I mounted two old trolley wheels rigidly on a side door jamb and found that by looping the banding wire around them as many times as necessary it was possible to band armatures with very little help. If additional tension is required on the wire, it may be easily obtained by placing a weight on the banding wire spool, as shown in the illustration.



The band wire is looped around two small wheels.

Comerio Falls, FREDERICK KRUG.
Bayamon, Porto Rico.

Transfer Cards for Equipment Keep Records Up-to-Date

INVENTORY systems should tell the location as well as the value, age, make, size, type, and so forth, of every item of equipment in a factory. This information is urgently requested by the fire insurance companies who also recommend making up blueprints showing the various machines on floor or department layouts. In order for the inventory records and blueprint layouts to be of real value, they should be kept up-to-date—in fact, up-to-the-minute. The writer has tried several methods of attaining this end and has finally adopted a transfer card system which has shown very good results in several plants.

The foreman of each department is instructed by the works manager, superintendent, or whoever is in authority, that no machine or other piece of equipment is to be moved without a transfer card made out and signed by a foreman and countersigned by the works manager. The boss millwright who does the moving and installs the machinery is also given the same instructions. In other words, no machine is moved until a transfer card, properly made out and countersigned, reaches him. The illustration shows the form of transfer card which we use. It could, of course, be varied if necessary to suit conditions in other plants. The cards, which are approximately 3⅜ in. by 5¼ in. are printed on thin paper in three different colors, white, pink, and blue, and are arranged in pads in that order. By the use of carbon paper all three copies are filled out in detail by the foreman in whose department is located the machine to be moved. The three copies are then sent to the works manager, who countersigns them if the move is sanctioned by him. The white copy goes to the millwright who takes it as authority to proceed to move and install the machine in question. The pink copy goes to the cost, or inventory department, and the blue copy to the plant engineer or to whomever is assigned the task of keeping the layouts up-to-date.

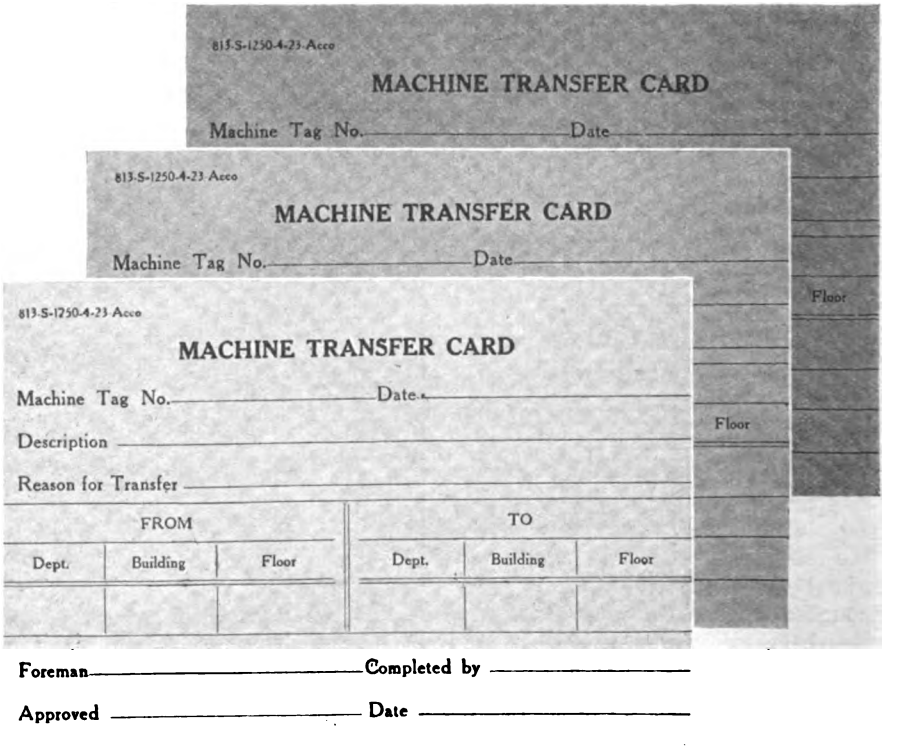
After the millwright has completed the job he O.K.'s his copy of the transfer card with his name, and date, and sends it to the plant engineer. Upon receiving it the plant engineer investigates the new location of the machines and shows it on the department layout. After making any notations he may desire on his blue copy of the card, he files it away and forwards the white copy to the inventory department. Thereupon the inventory department makes the necessary changes on their record. The white copy is again forwarded to the works manager and is filed away, completing the cycle for this particular transfer.

In case a new machine has been bought and is to be installed, the boss millwright makes out the cards and sends them to the works manager for approval. On the other hand, it may happen that a small machine, say, a stencil machine or an arbor press, is to be moved and does not require the services of the millwright department; nevertheless, in order to keep the records straight a transfer card should be made out.

D. FLIEGELMAN.

American Chain Company,
Bridgeport, Conn.

These cards must be properly filled out and approved before a machine or other piece of equipment may be moved.



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Handling Materials



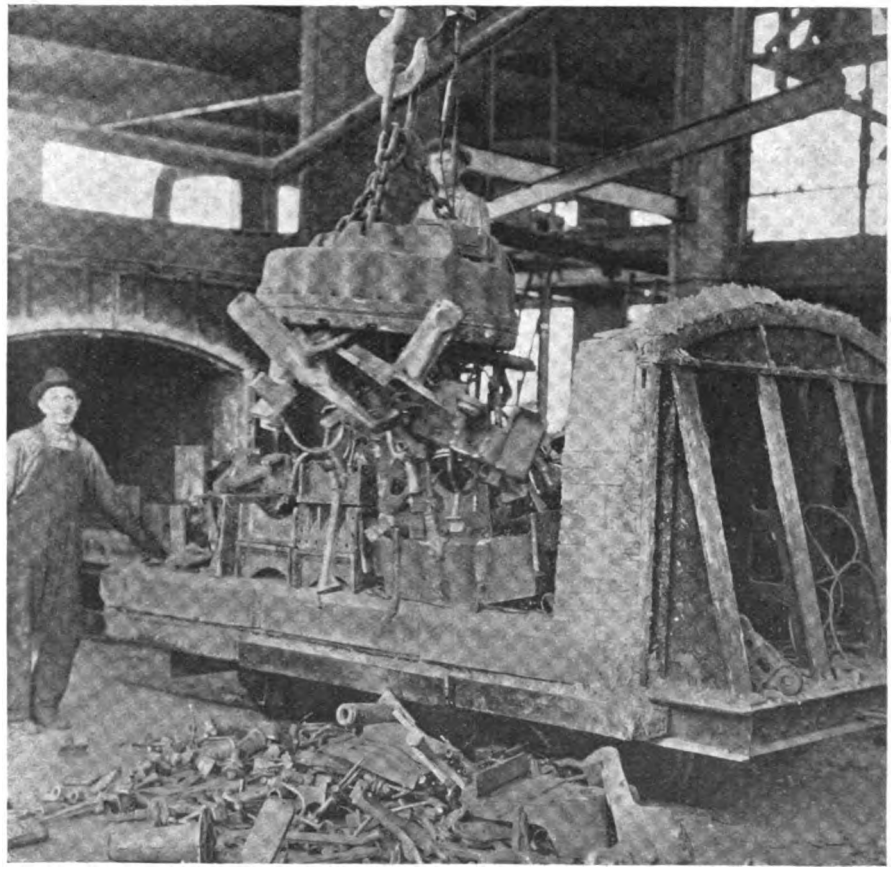
Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Increasing Production by Using a Magnet to Load and Unload Cars and Thus Save a Day Between Operations

ONE OF the big advantages of many material-handling installations is that after the equipment is installed it not only facilitates the handling of materials between processes but also, in many cases, enables the process to be speeded up. Sometimes this increase is unanticipated; in other cases the saving is forecast and is one of the direct reasons for introducing material-handling equipment.

Such was the case at the Milwaukee, Wis., plant of the Meynard Steel Company where a 36-in. magnet, as shown in the accompanying illustration, was installed purposely to speed up the production of the annealing furnaces. Originally, investigation indicated that a new furnace must be added to take care of increased production demands. However, further study showed that due to the long periods of idleness between charges, the furnace was not operating as effectively as it might if this idle period could be shortened. Because of the heat it was obviously impossible to unload the charging cars by hand until they had cooled somewhat. Ordinarily four and one-half hours have been required to unload a car; in addition six hours have been required to reload it, making altogether an idle period of ten and one-half hours, or a full day, lost in production. By using a 36-in. Cutler-Hammer (Milwaukee, Wis.) magnet the unloading period was reduced to one-half hour and the loading period to one hour, or a total of one and one-half hours, as against ten and one-half hours. In this way, the operation of the annealing furnaces is practically continuous, as with only one and one-half hours wait between charges the furnace can be filled and put in operation the same day it is unloaded and before it has become cold.

The same magnet handles the hot castings either in loading or unloading cars, or in delivering the castings to tumblers. It is also used to carry the finished castings to the delivery floor and to the trucks. In this way, the magnet not only has increased the production of the furnaces, but it also does a good deal of other handling work in addition.



By decreasing the time between charges—a material-handling problem—production work has been increased without the necessity of an additional annealing furnace.

Through loading and unloading the charging cars for this annealing furnace by a lifting magnet, the idle time between charges was reduced from ten and one-half hours to one and one-half hours. In this way a furnace was back in production inside of a few hours before it had time to become cold instead of being idle a whole day between charges.

Speeding Shipments By a Conveyor System and Special Packing Bench

ONE OF the big problems in most packing and shipping departments is to remove the filled boxes or packages as quickly as possible and with a minimum of effort to the

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packer. Often these packages are heavy when filled and are a load if they have to be lifted down from the bench to the floor or onto trucks. In addition, there is the task of trucking, perhaps to an elevator and down to a lower floor, which requires not only considerable time but takes one or more men. In the meantime these boxes are piling up in the way of the packers while they should be removed as soon as the packers are through with them.

Practically all of this lifting and trucking as well as the lowering by elevators is eliminated at the Chicago warehouse of Valentine and Company, varnish manufacturers, by an installation of two conveyor systems. In both warehouses the varnishes and enamels are received in case lots from the factory and stored on the second and third floors. Orders and shipments consist of various assortments of the numerous sizes of cans and colors. In one warehouse all packing is done on the second floor, as shown in the upper of the two illustrations accompanying this item. Orders picked on the third floor, either partially filled or complete, are placed in a box and sent down the spiral chute, shown in front of the window, onto the straight roller section of conveyor in the center of the packing table. The packer pulls the container over to the edge, onto his bench, packs and nails it up. The address and other necessary shipping instructions are stenciled on it and the box pushed onto the roller section again where it is carried down the chute and slide shown in the foreground to the section of roller conveyor and spiral chute shown in the lower of the two illustrations. This section of conveyor was installed by The Dow Company, Louisville, Ky.

The packer can permit the filled boxes to accumulate on the spiral section of gravity conveyor, shown in the lower of the two illustrations, until it is filled to the second floor. Then one of the packers can come to the first floor, remove the boxes and truck them to a section of the floor allotted to freight shipments. Shipments for each railroad are placed together along one wall in a space indicated for them. Each morning these are loaded up by truck and taken to the various freight houses.

The plank platform extending upright over the doorway in the background of the lower of the two illustrations is a drawbridge which may be lowered over a driveway between two buildings or may be used as a platform from which to load trucks.

In the other warehouse, which is about 100 ft. away, packing is done on both the second and the third floors. A switch enables packages from the third floor to be shunted off at the second floor. Here, however, the arrangement is not such that the packages can go direct from the packing bench to the conveyor, but have to be lifted down and trucked across to the opening in the floor. Over 100 ft. of roller conveyor (Mathews Gravity Carrier Company, Elwood City, Pa.) extends from the second floor of this warehouse to the first floor or shipping room of the other warehouse previously mentioned. This conveyor, because it is necessary to leave a driveway, and the yard space between, clear and free from obstructions, skirts the buildings surrounding the yardway and so is necessarily several feet longer than would be the case if it could go directly across. As this section of conveyor between the two buildings is outdoors it is built over or enclosed with sheet-iron which gives it the appearance of a tunnel.

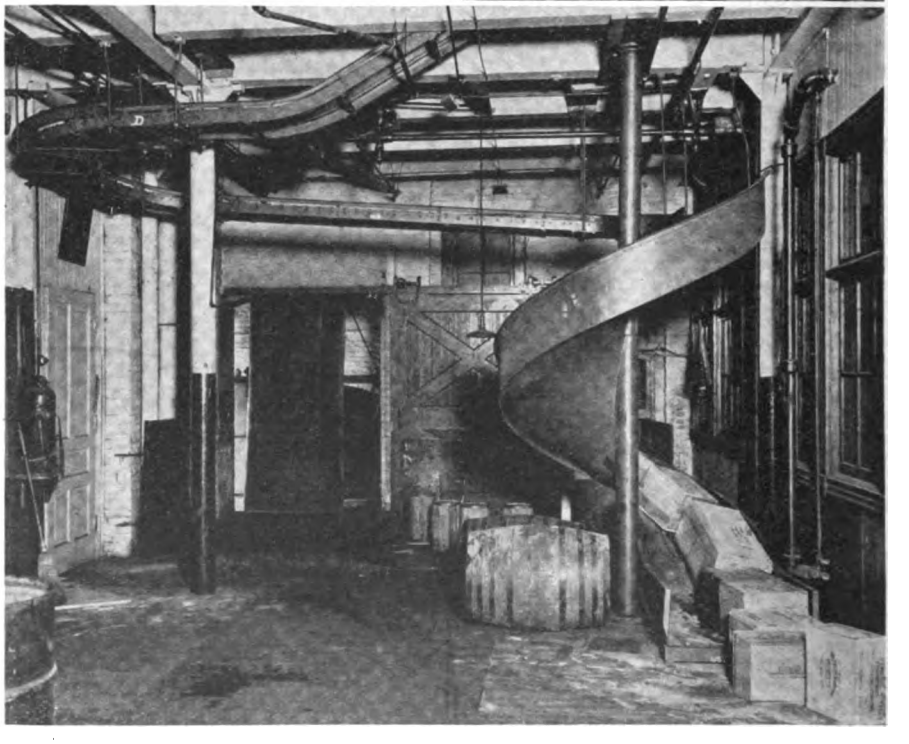
Without these conveyors it would probably require the entire time of one man in each building to load up these boxes on the second or third floor, where they are packed, take them to the elevator, lower them to the first floor and truck them across to the other building. By lowering the cases by gravity conveyors and special chutes, the elevators are reserved for bringing in cases of new stock as received from the factory. Approximately six carloads of varnishes and enamels are received from the factory in case lots each month. These are sent out in many small assortments.

Although about the same number

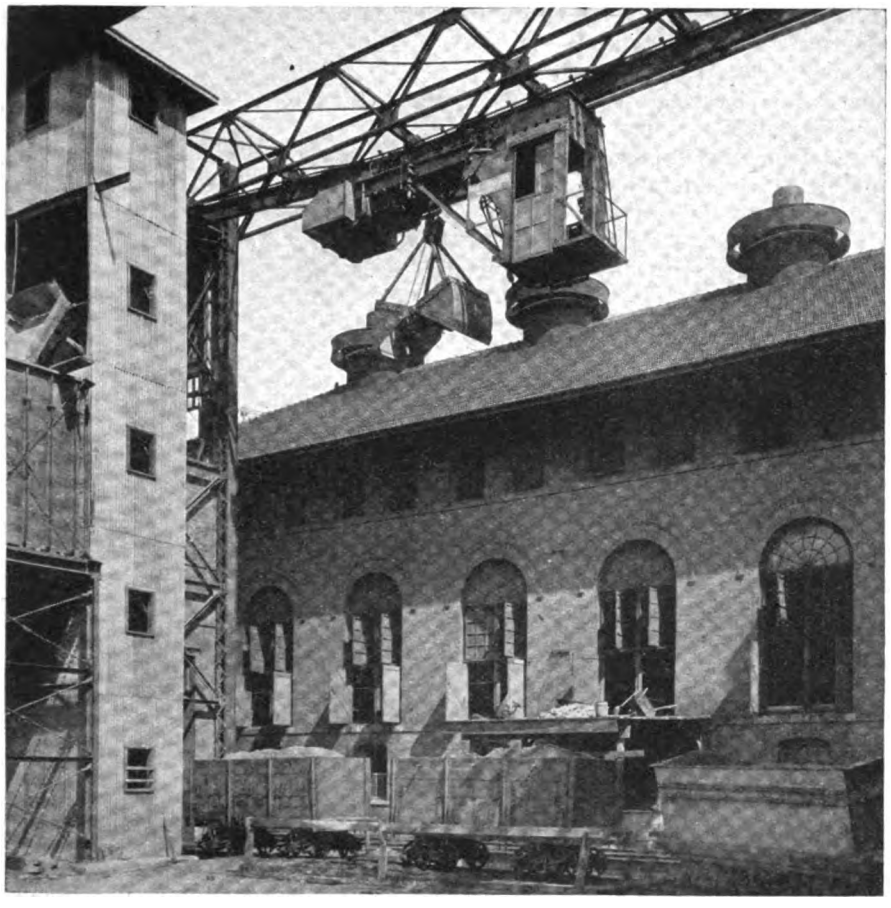
This conveyor system speeds up the shipment of orders of varnish.

When a man has finished packing a box of varnish or enamel, he simply pushes it over onto the roller section in the center of his packing table and it is carried down to the first floor by the conveyor system shown in the lower of the accompanying illustrations. Here it is distributed to the space allotted to shipments on the various railroads leaving Chicago. Because the packer does not have to give any of his time to removing the packed shipments out of his way he has more time for packing. Orders are picked from the cases in the background or from similar cases on the floor above. All the packing in this building, however, is done on this packing table and conveyor system. Orders are filled in another warehouse some distance away and carried to the same first floor distributing room by another conveyor not illustrated here. This leaves the elevators free for handling incoming stock.





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Here the operator handles about fifty tons of coal an hour.

By using a 40¼ cu. ft. bucket on this 3-ton hoist a day's fuel requirements of approximately fifty tons are transferred from the hopper, in which they are dumped by the railroad cars, to the storage bunker in about an hour. The out-of-the-ordinary method of mixing the two kinds of fuel by the bucket is explained in the item.

of men are used now as before this system was installed, the volume of work handled is much larger. It is rather difficult to estimate how many men would be required for operating under previous conditions. It is safe to say, however, that more men would be required and also it would be impossible to get the shipments out on such a narrow margin of time as is possible now. This is a most important feature and considerable emphasis is laid on quick delivery, as many dealers order only when their stock is exhausted and they want the shipment immediately.

Handling and Mixing Fifty Tons of Screenings and Coke Breeze in an Hour

HANDLING COAL around an industrial plant is one of the somewhat infrequent or irregular jobs which in many places is now being done by electric cranes and hoists. One of the greatest advantages in this use lies in the fact that with such equipment the large gangs of men which are ordinarily used for this purpose, are eliminated. Also, despite the irregular nature of the work only the operator and perhaps one or two other men are idle during any waits between handlings. These, however, usually can find plenty of miscellaneous jobs to keep them busy for such a short time. Where considerable quantities of coal are used these hoists and buckets are operated economically a large portion of the time. For example, at the Milwaukee Gas Light Company, Milwaukee, Wis., the 3-ton Pawling & Harnischfeger (Milwaukee, Wis.) hoist shown in the accompanying illustration is equipped with a 40½-cu. ft. No. 110 Blaw-Knox bucket for handling coal outdoors. Here the hoist is operated on a 15-in., 50-lb. monorail beam. About 50 tons of either anthracite screenings and coke breeze or Illinois screenings and coke breeze are used under the boiler daily. This fuel is obtained from the local coal stocks on railroad cars and the coke breeze is taken from storage. The fuel is dumped into concrete-lined hoppers beneath the railroad tracks and mixed before delivering to the overhead bunker. Ordinarily mixing would require either a large gang or elaborate equipment. However, in this case it is done by the bucket which picks up the fuel, hoists it and drops it back into the hopper.

Here the action of a bucket is quite similar to mixing by hand. Thus, in a short time the entire lot is mixed evenly enough for the purpose. The hopper capacity is 118 tons while the bunker capacity is 180 tons. Approximately fifty tons an hour are handled by the bucket when working out of the hopper to the bunker. Here the hoist is 45 ft. and the trolley travel 75 ft. The narrow-gage cars shown in the foreground are used to transfer ashes. The hopper is just at the other side of the car.

Using Conveyors for Handling Hot Materials Between Operations or Processes

MATERIALS which are still hot or even too warm to handle offer a type of problem which is quite common in many industries. Pieces which are quite small are frequently handled with a fork or shovel. With larger pieces it is usually necessary to provide some sort of hook to pick them up.

For transfer, conveyors are being used in many plants. Sometimes these conveyors are short—only a few feet in length—to reach from the furnace door to a special lift truck skid. In other cases they are longer and are used to carry the objects needed to the next operation or to a cooling space. One very common use is in carrying the hot case-hardening boxes from the furnace to the quenching tank. In this way one quenching tank can easily handle the work from several furnaces, while the conveyor delivers the box from the furnace to the tanks much more quickly than if the box were closer but had to be lifted across by tongs.

For this work gravity roller conveyors are frequently used, especially if the distance is short. Where the material must be handled some little distance or the pieces are too small to travel on rollers, or the boxes must be elevated, slat or apron conveyors are more frequently used. The use of conveyors not only speeds up the work but also enables one man to do what ordinarily would require three or four. Also, as the man does not have to touch the work by hand, there is much less opportunity to receive serious burns or other injuries.

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Shutdowns Have Been Prevented

(Continued from page 287)

The necessary supply of materials for maintenance is kept on hand in the electrical department. These supplies consist of fuses, lamps, and general repair parts of the equipment used. Table II gives a list of the most important spare equipment kept on hand. The department has available approximately 700 hp. in spare motors in sizes varying from the smallest to the largest used. The cost of lamps used per year amounts to about $2,000 and the cost of all other repair equipment is likewise approximately $2,000.

Lock-type lamp guards are used and the keys are kept by the department foreman. All lamps are stamped with the company's name on the globe. A rubber stamp and special ink is used. The stamp was furnished by the Etch-O-Lite Company and Reed glass-etching ink is used.

The department has a good assortment of portable indicating and graphic measuring instruments, which are kept in constant use. These are listed in Table III. These instruments are carefully calibrated by outside parties about three times a year to see that they are in perfect order.

Industrial Maintenance Service

(Continued from page 292)

The size of the form we use is approximately 6x10 inches. These forms are bound in a loose leaf type of binder of rugged construction. A separate sheet is made out for each motor in which a defect is found. The sheets of form No. 1 are taken out of the binder at the completion of inspections and filed until the end of the month when they are used in making up a detailed report shown as form No. 2. This form is made in duplicate, the original sent to the customer and a copy kept on file.

The importance of these monthly reports can not be over-estimated. They serve as a means of showing the amount of attention devoted to equipment and are the guides which customers use in making repairs.

When the confidence of the customer is established in service of this character there is opened up a market for motor equipment in most cases without competition. The profits from this source are an item worthy of consideration, since the selling expense is low.

How to Reclaim Leather Belts

(Continued from page 309)

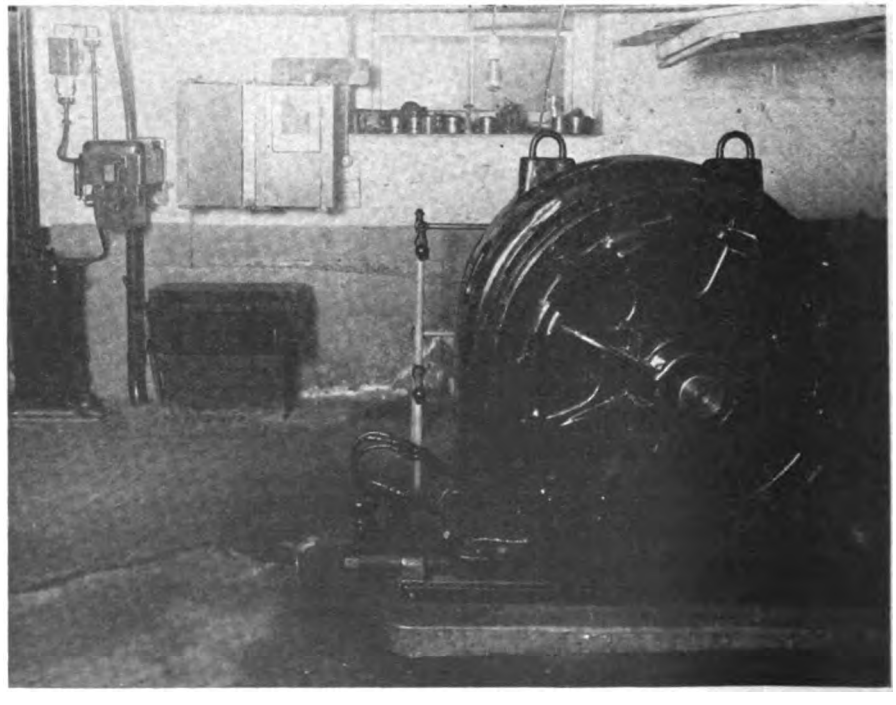
to scrape down a lap for a joint to an even bevel, and to make sharp edges on the laps.

The author wishes to acknowledge special assistance from Louis W. Arny, secretary, The Leather Belting Exchange; J. R. Hopkins, Chicago Belting Company; F. F. Raniville, F. Raniville Company; H. R. Slivinski, Deering Works, International Harvester Company, Chicago; R. C. Moore, Chas. A. Schieren Company; M. W. Edgar, Detroit Belt Lacer Company, and R. H. Whitney, The B. F. Goodrich Rubber Company, in the preparation of this and other articles which have appeared in this series on belts for industrial purposes.

Editor's Note: Acknowledgment is made to the following companies for assisting in furnishing information and photographs for this and the other articles which have appeared in this series. The Leather Belting Exchange, 119 S. Fourth St., Philadelphia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; Birdsboro Foundry & Machine Co., Birdsboro, Pa.; The Bristol Co., Waterbury, Conn.; The Chesapeake Belting Co., Baltimore, Md.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Belt Lacer Co., Detroit, Mich.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co., Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Goodyear Tire & Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; The Monarch Belting Co., Cleveland, Ohio; New York Rubber Co., New York, N. Y.; F. Raniville Co., Grand Rapids, Mich.; J. E. Rhoads & Sons, Wilmington, Del.; W. H. Salisbury & Co., Chicago, Ill.; Chas. A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Machinery & Supply Co., New York, N. Y.; The Taylor Belting Co., Indianapolis, Ind.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

A Correction in "Operating Conditions Affecting Belt Service"

THERE IS one point in the second article of the series on belts, "Operating Conditions Affecting Belt Service," in the April issue of the INDUSTRIAL ENGINEER, that I want to particularly call to your attention and which, I believe, you will wish to correct. In the table which you use on page 194, "Minimum Pulley Diameters Recommended for Different Speeds and Weights of Rubber Belts," you show pulley diameters and in the second column give speed in feet per minute, whereas this should be revolutions per minute. However, any analysis of this table considering the figures



This illustration shows one of four 125-hp. induction motors driving compressors. It was originally a 220-volt installation but has been rewound for 200 volts.

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given as "belt speed" rather than "pulley speed" will make the whole thing seem ridiculous.

I find that one of the greatest difficulties which we have in giving the average man the right conception of high-speed work is in differentiating between pulley and belt speeds. Of course, as a matter of fact, the actual belt speed, until we get up into very high figures and unusual conditions, is not anything to worry about but the worst of the so-called high-speed, small pulley conditions are encountered where the actual belt speed is probably not over 2,400 ft. per min. From the point of practical application, it is well to consider the pulley diameter and revolutions per minute rather than the linear velocity of the belt. I trust that you will be able to handle this matter in one of your subsequent issues so that it will make the table given appear more reasonable, and I am extremely sorry that I did not make this more clear at the time of sending the table in.

R. H. WHITNEY.

The B. F. Goodrich Rubber Co.,
Akron, Ohio.

Unequal Grouping of Coils

(Continued from page 303)

is, as stated before, the lowest number into which the number of phase groups and the number of slots will each go a whole number of times. In the example shown the number of dots equals 720. As there are twenty poles each horizontal line contains (720 ÷ 20) or 36 dots. Then dividing the total number of dots (720) by the number of slots (144) we get an answer of 5. Thus there are 5 dots for each slot. Therefore every fifth dot is replaced as shown by an *O* which represents one side of a coil. The dots are divided vertically by lines, as shown, into three parts which represent the three phases.

"One side only of each coil is shown in the diagram, the other side is to be taken care of by the pitch-factor.

"The first use made of this 'L. C. M.' diagram was about eight years ago in changing two 750-kw. generators from 25 cycles to 60 cycles. They were originally 32-pole, 94-revolutions per minute, 288-slot, three-phase machines, and they were changed to seventy-six poles, sixty cycles, three-phase using new rotor poles and a new stator winding of 144 coils, but with the old stator core.

"Such induction motors built so far with the unequally-grouped windings have been found on test to have balanced phases when running lightly loaded, loaded and locked.

"The coil connections for a single-primary, two-speed, two-phase induction motor may be readily written out from the two 'L. C. M.' diagrams for the different numbers of poles. A controller for such a motor must do but three things regardless of the number of poles: Leave certain coils in circuit as they were, transfer other coils from one phase to the other without reversal, and transfer the remaining coils from one phase to the other and reverse them. The controller changes for a two-speed, three-phase, single-primary induction motor will be very much more complicated.

"The above form of 'L. C. M.' diagram on section paper will also be found to be very convenient for locating the equal-potential cross connections in multiple two-circuit armature windings as used in direct-current machines."

Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

F. Raniville Company, 241-247 Pearl Street, Grand Rapids, Mich.—A circular describes Raniville's "Newply Rebuilt" process for leather belts. This consists of taking usable sections of old leather belting, and putting them through the "belt laundry" where they are cleaned and treated. They are then separated into single-ply belting, the joints opened, and recemented with a piece of new leather on the back, making a double belt. The face of old leather is used next to the pulley with the new leather on the outside to give it strength.

Roller-Smith Company, 233 Broadway, New York City—Bulletin 30 on "Roller-Smith Triplex Ammeter for 3-Phase A.C. Circuits," covers a new type of ammeter recently developed. Among the features claimed for this are that it is possible to take readings of three phases simultaneously by means of three ammeters built in one case.

The Monarch Belting Company, Cleveland, Ohio—A folder entitled "Efficient Belt Transmission" describes the Monarch pulley covering which may be used on steel, cast-iron, wood, fiber or leather pulleys to increase the gripping contact of belts. One of the interesting features of this bulletin is a "Question Box" in which ten questions are asked and answered concerning this covering.

Gund Manufacturing Company, La Crosse, Wis.—A folder describes Gund's adjustable shaft hanger. This is claimed to be adjustable in three ways—in the perpendicular or transversal or on the diagonal—so that a shaft may be placed in the proper position in less time than is ordinarily required.

The Thomas-Smith Company, Canton, Ohio—Catalog 3 illustrates and describes various types of bells for alarm and signal systems.

D. O. James Manufacturing Company, 1114-24 West Monroe Street, Chicago, Ill.—Bulletin 8 contains over a hundred pages devoted to the James speed-reducing transmissions. Numerous sectional and phantom views show the design and construction of the gear and worm speed reducers. A number of pages is devoted to illustrations of installations and to tables giving the ratings of the various types and sizes of reducers.

The Hill Clutch Company, Cleveland, Ohio.—Catalog 8 on friction clutches describes and illustrates the care and operation of The Hill Clutch Pulleys. Instructions for ordering repair parts are included as well as a description and illustration of each separate part, together with its name. Prices for each of the various sizes of repair parts are also included as well as a number of data tables of interest to the engineer.

Smooth-on Manufacturing Company, 570-574 Communipaw Avenue, Jersey City, N. J.—The various uses of "Smooth-on" iron cement No. 7 for making hard, dustproof and oilproof concrete floors, for waterproofing concrete and for oilproofing as well as for repairing holes or cracks in concrete, brick, or stone work, are described and illustrated in a 32-page booklet. A number of out-of-the-ordinary repairs is illustrated.

Square D Company, Detroit, Mich.—Bulletin 30 describes the latest industrial safety switch produced by the Square D Company. This switch embodies several distinctive features, such as unit bases of moulded composition for each jaw and fuse clip instead of the older type slate base. Also, porcelain protective covers enclose each line terminal so that even when the switch cover is open no live parts are exposed. Other features are a positive quick make and break action, as well as an automatic cover control which makes it impossible for anyone except an authorized person with a key to open the cover when the switch is on.

The Service Products Company, Springfield, Ohio—A loose-leaf catalog lists

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and describes the various electrical test units and other equipment which this company makes. Much of this is for automotive service station equipment.

Graver Corporation, East Chicago, Ind. —Bulletin 509 describes the Graver "Zeolite" water softener. Several phantom views show the operation of the equipment and a short discussion is included of the chemistry of water-softening.

The Leland Electric Company, Dayton, Ohio—A 4-page bulletin describes and gives prices on the various types of Leland non-stalling, cool-running, 30-deg. motors. These motors are made in from ⅓ hp. to 1 hp. rating. All single phase a. c. motors are repulsion induction and all d. c. motors are compound wound. The bulletin illustrates the eight different types of frames supplied for these motors.

The Electric Welder Company, 327 Permanent Building, Cleveland, Ohio—Bulletin 23 describes the resistance welder Type S. A. F. Dimensions and capacities of the various sizes are given together with the features which are claimed as distinctive improvements for this equipment.

Ashton Manufacturing Company, Newark, N. J.—Circular "B" describes the Ashton "Red-Hot" gasoline fire pot and blow torches. Among the advantages claimed for this firepot is an improved double-needle burner.

The Standard Electric Tool Company, Cincinnati, Ohio—A group of catalogs describes the line of Standard portable electric drills, reamers and grinders for universal, direct current and single-phase alternating current of 60 cycles or less. The grinders are made in portable, pedestal and tool-post types.

The Leonard Electric Manufacturing Company, Cleveland, Ohio—Bulletin J describes the Leonard safety switch and safety power panel. Sketches show the safety features as well as the quick make-and-break and operating mechanisms. The power panels are made up by grouping in a panel board several safety switches.

Aetna Abrasive Company, 1463 West Ohio Street, Chicago, Ill.—A folder lists the various types and grades of Aetna cutting and smoothing commutator stones as well as the use for which they are recommended.

The United States Electrical Tool Company, Cincinnati, Ohio—Catalog 20 illustrates and describes the wide line of United States electrically-driven tools. In this are numerous types of electric drills, drill stands, electric screwdrivers, grinders for using in tool posts of metal working machines as precision grinders or for external or internal grinding, portable surface grinders, as well as electrically driven, direct-connected bench and pedestal grinding outfits.

Burke Electric Company, Erie, Pa.—Bulletin 127 describes the electric arc welding equipment, stationary or portable type, with either electric or gas engine drive. Several pages are devoted to showing types of repairs which may be made by electric welding.

Electro-Service Company, Atlanta, Ga. —A folder describes the Bennett surge arresters, which are claimed to have no fire hazard. The construction and operation are shown and explained by a sketch.

The Divided Pole Electric Company, 2400 Woodland Avenue, Cleveland, Ohio — Recent literature makes announcement of a new type of dynamo electric machine which is to be used as a rotary transformer for transforming alternating current to direct current or from one voltage to another. Some of the advantages claimed for it are its light weight and low cost. It is made in two sizes, 150 amp. and 200 amp., for welding. This folder illustrates the features of construction of the rotary transformer which gives the advantages claimed for it.

Gillis & Geoghegan, 537 West Broadway, New York City—Pamphlet 280 illustrates and describes the equipment used with the G. & G. telescopic hoist to save labor. One of the most common uses of this equipment is for removing ashes through sidewalk openings, although it can be used for many other industrial applications.

The Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Leaflet 2390-A, describes and illustrates the construction of Type E engine-driven alternating-current generators from 50 to 300 kva. These generators are applicable to all prime movers and are suitable for direct connection to steam, gas, and oil engines, or slow speed horizontal water-wheels.

The Hergi Manufacturing Company, 250 Fifth Street, Bridgeport, Conn.—Catalog 17 describes the Hergi flexible shaft equipment especially adapted for grinding and screw driving. One set of grinding attachments comprises twenty-five different grinding tools which are listed and illustrated.

Link-Belt Company, 910 South Michigan Avenue, Chicago, Ill.—Book 600 describes "Link-Belt Material-Handling Equipment for Foundries." Thirty-two pages are devoted to illustrations and descriptions of installations of conveying equipment in foundries. Several drawings show the details of these operations and a careful description shows the production which has been made due to this installation. In addition to the features which are ordinarily found in catalogs this compares in print and picture the practices and methods of six large and nationally-known foundries where by the use of material-handling equipment, production was increased, labor shortage overcome and economies made in time and money—problems which confront every foundryman.

The Thompson Electric Company, 226 St. Clair Avenue, N. E., Cleveland, Ohio—A supplement to catalog B-21 describes the installation methods and conduit wiring features for installing the Thompson system of lamp maintenance hangers. In this system the fixtures are lowered for renewal of lamps or cleaning reflectors thus eliminating all climbing or electrical hazards.

Whiting Corporation, Harvey, Ill.—Catalog 165 on "Whiting Cranes" describes the various types of jib, bridge and gantry electric cranes. In addition to illustrations and descriptions of the principal points of construction of these cranes, considerable space is given to descriptions and illustrations of their use as material-handling equipment.

Chicago Belting Company, 113-125 North Green Street, Chicago, Ill.—A series of circular folders takes up a number of the important features of leather belting manufactured by the Chicago Belting Company. The first of these folders is on the subject of "Identifying Leather Belting Quality"; the second "Tested Leather Belting." Others take up other features of leather and belting.

Watlow Electric Manufacturing Company, 1409 Pine Street, St. Louis, Mo. —A folder describes the Watlow electric box toe steamer, which is used to supply steam for shoe work. It is claimed that this will supply abundant steam of the proper dryness for 10 cents per day, and requires filling with water about once a day.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—A folder describes the type NC 40-deg. motor. One of the features of this is a diagram showing the construction with arrows pointing to special features, which are described.

Canedy-Otto Manufacturing Company, Chicago Heights, Ill.—Catalog 22 describes the line of automotive and other repair shop equipment such as drills, punches, shears, shrinkers, motor shafts, grinders, buffers, forges, blowers, tuyere irons, and other tools. Particular attention is called to portable cranes for lifting work to or from machines or while making repairs.

Acorn Leather and Belting Company, Detroit, Mich.—A small folder lists the advantages of remanufactured belts by the "Neu-Ply" method. This is a process of re-manufacturing and reclaiming leather belting by rebuilding old belt on a new ply of leather.

The Bristol Company, Waterbury, Conn.—Catalog 712 describes the complete line of Bristol belt fasteners. These consist of patent steel belt lacings, belt plates, rivets, flexible wire belt lacing and belt hooks. In addition the size of fastener recommended for each type and size of belt is given.

The Norma Company of America, Anable Avenue, Long Island City, N. Y. —Pamphlet No. 13 entitled "Hoffmann Bearings and Their Use and Influence on Electrical Machinery," describes a number of installations where the Hoffman bearings are used on electrical equipment. These bearings are made in England but distributed in the United States by The Norma Company.

Universal Electric Controller Co., 103 S. Wells Street, Chicago, Ill.—A folder describes the construction and uses of the Universal Electric Controller. This is a potentiometer, resistance device for reducing 110-volt direct current to any desired voltage for operating bells, telephones, fire alarms and other low-voltage signal systems directly from power and lighting circuits. The design of the instrument is such that it shows at a glance whether 110-volt power is on, and also automatically indicates the presence of grounds and shorts in the low-voltage circuits.

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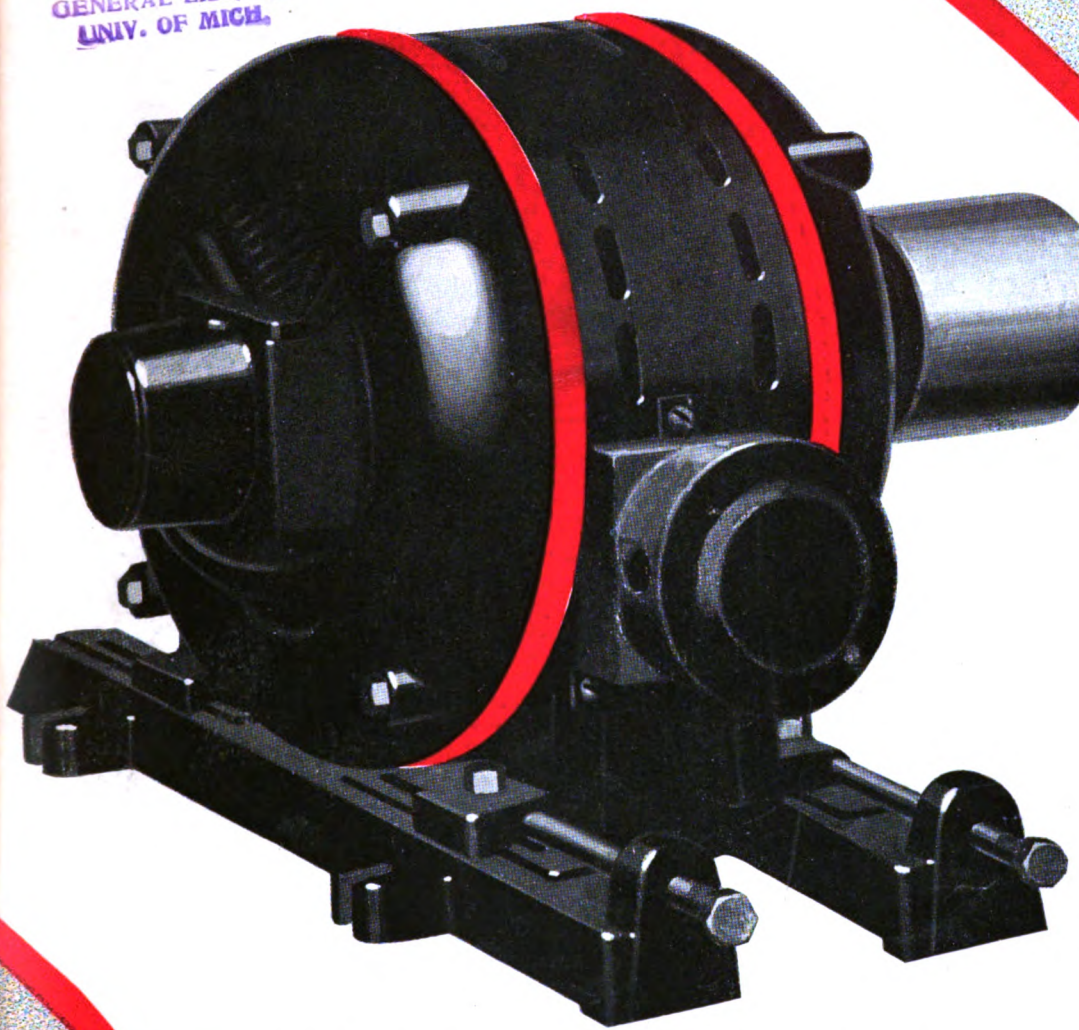
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

July, 1923

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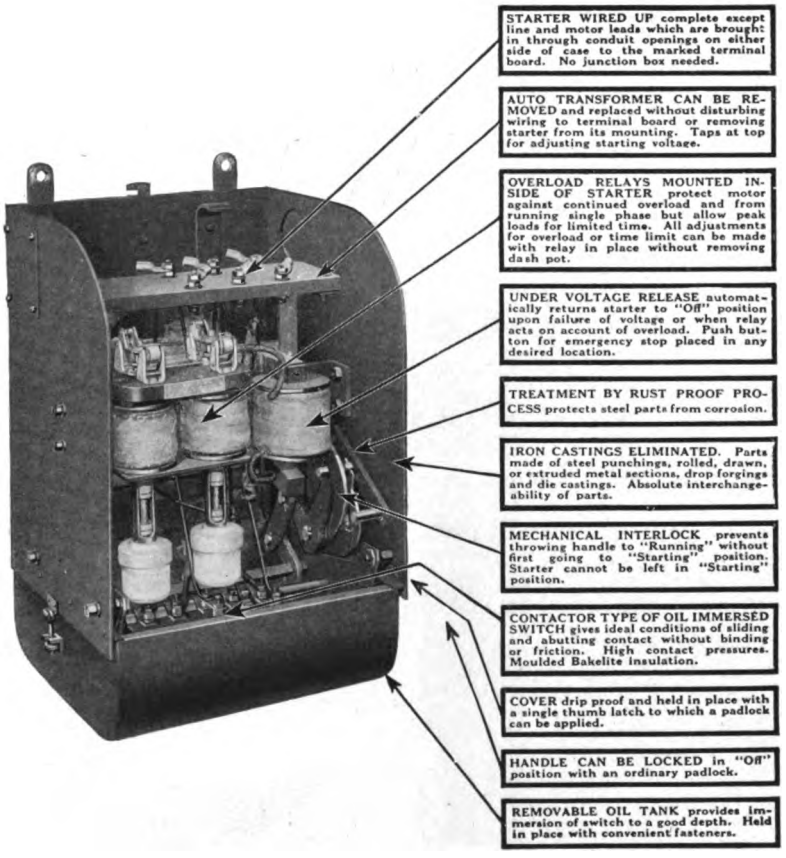
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Type "R" Potential Starters

For Squirrel Cage Induction Motors



TYPE "R" POTENTIAL STARTERS
With Cover removed to show Mechanism

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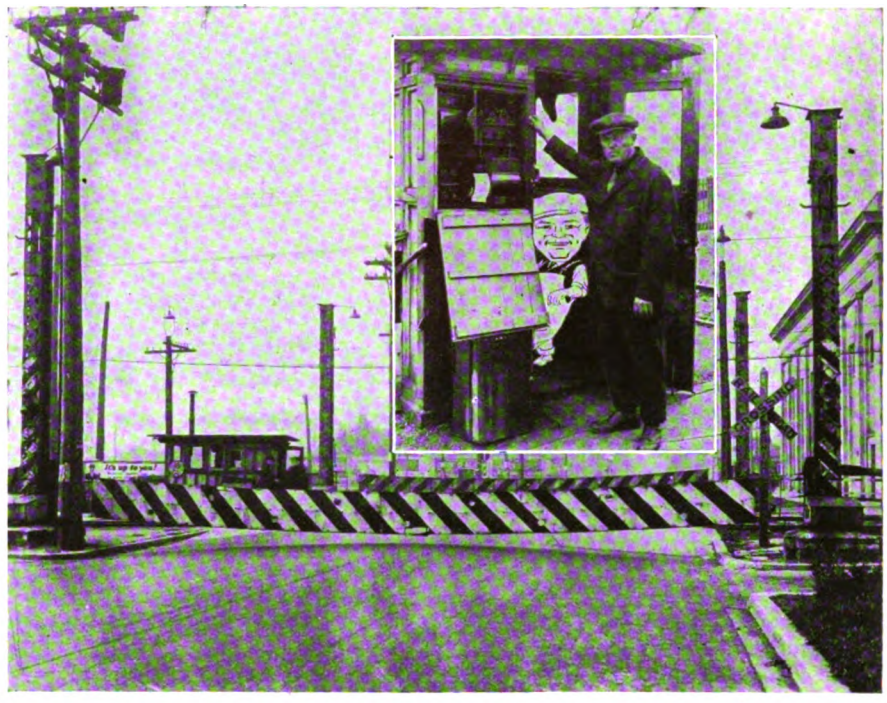
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, July, 1923 *Number 7*

Here Is Some Good Service Evidence

On the Operation of Knife-blade Switches that Shows How Much Abuse They Will Stand



ACTUAL service is the final test which all apparatus must stand. It is the qualified judge of satisfaction and the starter for some prolonged arguments on ought-to-be and should-be theoretical operations with the practical man on one side and the technical expert on the other. Usually there is a compromise and something good comes out of it after all.

If you readers want to start such an argument here is a good chance. What will be the useful life of a knife-blade switch that is operated continuously every three to six minutes, without replacement of parts, in starting and stopping a 3-hp. motor?

The following letter which I recently received from J. E. McNeil of the Square D Company furnishes a starting point. He says:

"After reading the article in a recent issue on old motors which have withstood years of service I thought you might be interested in the following record achievement of safety switches.

"The other day I received a letter from Chicago telling me about four Square D switches that are used on the motors that raise and lower the gates at the Austin Boulevard crossing of the Douglas Park Branch of the Metropolitan West Side Elevated Railway Company in Chicago.

"The letter stated that these switches are operated twice every three to six minutes a day in raising and lowering the gates. They have been in service about two years and on the basis of operating an average of 500 times daily have successfully withstood the severe service of more than 350,000 operations. Frank Novotny, who wrote the letter says that they are still in good mechanical condition and working very satisfactorily. From all appearances they will stand many more operations before beginning to show signs of wear."

I don't want to spoil the chance of any one having his say on this subject nor do I want to put Mr. McNeil in the position of bragging about this performance. He didn't—he has simply furnished some information on switch operation that is mighty interesting and if any one else has other or additional service records I think he will be as glad to know about them as I am.

Incidentally, I might say that I went out to see this installation, since it is near our editorial office, and the pulling and closing those switches get is aplenty and would satisfy the greed of anyone who would like to try to wear out a switch in service. Yet they are still in good condition just as Mr. Novotny has pointed out.

The four switches are connected in the circuits of four variable speed, three-phase, 60-cycle 220-volt induction motors each of which is rated at 2.8 hp. These motors are located in sheet iron housings at the base of the supporting columns for the gates shown in the above photograph. They are protected by ITE circuit breakers, and limit switches.

Now then, if you have a switch installation in your works that has stood more abuse than these in two years, send me the details and a good picture. I'm making a collection of this sort of service evidence.

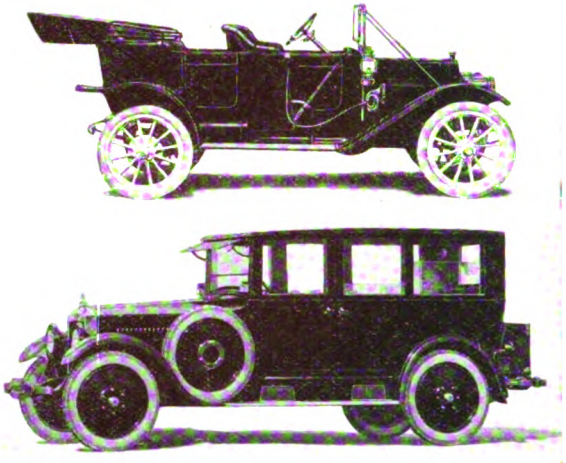
Practical Pete

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A Glimpse Into the Works of

The Studebaker Corporation of America

Where mass production and progressive assembly of the automobile have been an outgrowth of the carriage and wagon industry. The seventh of a series devoted to the growth and extent of our basic American industries.



How the car of 1910 looks alongside one of today.
Many refinements in appearance, construction and reliability have been made in automobiles in the past ten or fifteen years. Many readers will remember older cars.

THE AUTOMOBILE and the industry responsible for it are only thirty years old. During that time they have developed until now, according to the census of 1919, automobile manufacturing is our third largest industry. In 1922 approximately 2,340,000 passenger cars and 260,000 trucks were produced in the United States. Nor has the development been in the extension of manufacturing facilities alone. The "horseless carriages" of 25 to 30 years ago were extremely unreliable. Those who had the courage to try them never knew when they were going to stop. The automobile of today is probably as reliable as any other piece of equipment in common usage, not excepting many devices which are less complicated mechanically, and this reliability exists irrespective of the degree of mechanical ability or lack of ability of the driver. Along with this mechanical improvement has come a refinement in appearance and comfort. The uses to which automobiles are put are so varied that often it is a point of argument as to whether an automobile is a vehicle for pleasure or for business.

Probably the best indication of the growth of this industry is shown by the census report on number of wage earners. In 1899, about 2,000 wage earners were employed by the automobile, body and related industries. By 1904 these had grown to 12,000 workers; by 1909, to 76,000; to 127,000 in 1914 and to 343,000 in 1919, thus making it the seventh industry according to the total number of wage earners employed. Automobile manufacturers were responsible in 1919 for production to the value of $3,080,000,000. Of this, the cost of material is about 63 per cent of the total value of the manufactured product. This is in considerable contrast to the flour milling and packing industries, which were mentioned in previous issues, where the value of the raw material was between 80 to 90 per cent of the total value of the finished product.

In the early days of the automobile industry, an effort was made to put a gasoline engine into a buggy and for a number of years the design of the buggy was closely followed in the manufacture of automobiles. This naturally led many buggy and wagon manufacturers to enter in the automobile field. One of the most

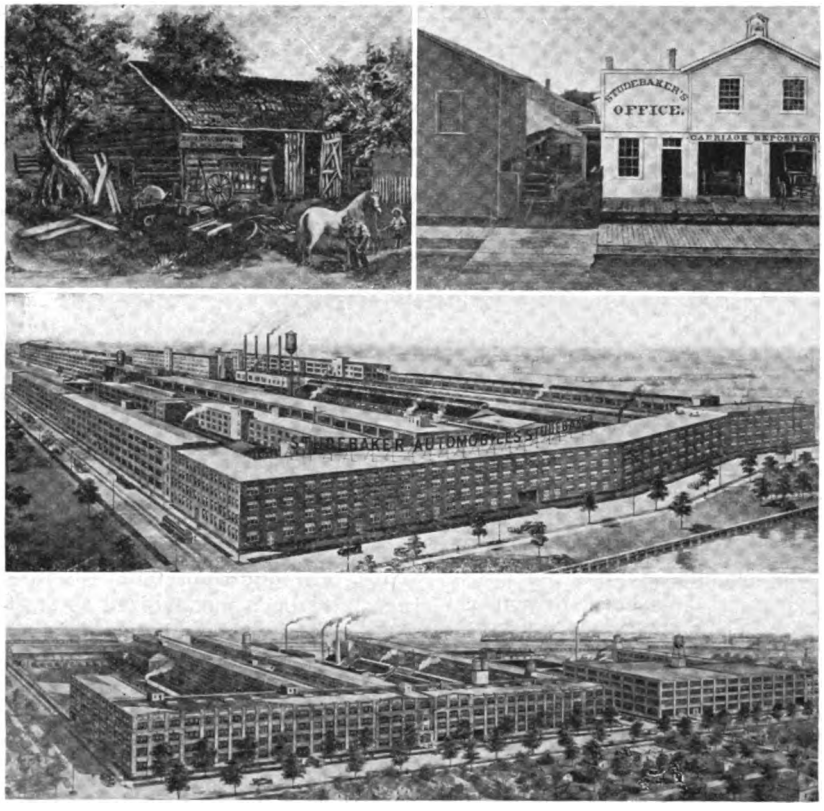
Plants No. 1, in the foreground, and No. 2, in the distant background, of the Studebaker Corporation at South Bend, Ind.
These two main plants of the Studebaker Corporation cover 150 acres with a floor space of 4,875,000 sq. ft. Plant No. 2 is the more modern and alone covers an area of over 100 acres. Altogether, the plants of the Studebaker Corporation, including those in Detroit, cover 225 acres, contain 7,100,000 sq. ft. of floor space, and have a capacity of 150,000 automobiles per year. Originally, the South Bend Works was a carriage and wagon factory. This part of the business has been disposed of and now the entire energy of the organization is devoted to the construction of passenger-car-type automobiles.



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The Studebaker Corporation dates its beginning from an enterprising, country blacksmith shop.

In 1852, two Studebaker brothers began the manufacture of wagons along with their blacksmithing. Their first office is shown at the right. By 1868 they were doing a $350,000 business annually and soon became one of the most prominent wagon and carriage manufacturers. In 1910 they bought a Detroit automobile factory and since then their organization has occupied a prominent position in the manufacture of gasoline cars. Four of the Detroit factories are shown in the accompanying illustrations. However, a large portion of the later developments and extensions of the organization has been at the South Bend Works.



prominent of these was the Studebaker Brothers Manufacturing Company, which is now known as The Studebaker Corporation. Approximately 71 years ago, in 1852, at South Bend, Ind., H. and C. Studebaker, blacksmiths and wagon makers, began business with a capital of $68 and two forges. Later three other brothers joined the business which in 1863 was incorporated as Studebaker Brothers Manufacturing Company, with over $200,000 assets. At that time its sales averaged about $350,000 annually.

For many years, Studebakers were one of the largest producers of horse-drawn vehicles. They were attracted early to the possibilities of the automobile industry for in 1897, according to the minutes of a board meeting, $2,000 was appropriated for building and experimenting with a "horseless vehicle." In 1902 the company actually launched into the building of electric runabouts and trucks, a business which it continued until 1912. About 1904 it began building, in connection with another company, gasoline-propelled automobiles known as the "Studebaker-Garford" cars. In 1910 it purchased an automobile company in Detroit and became a manufacturer of gasoline cars.

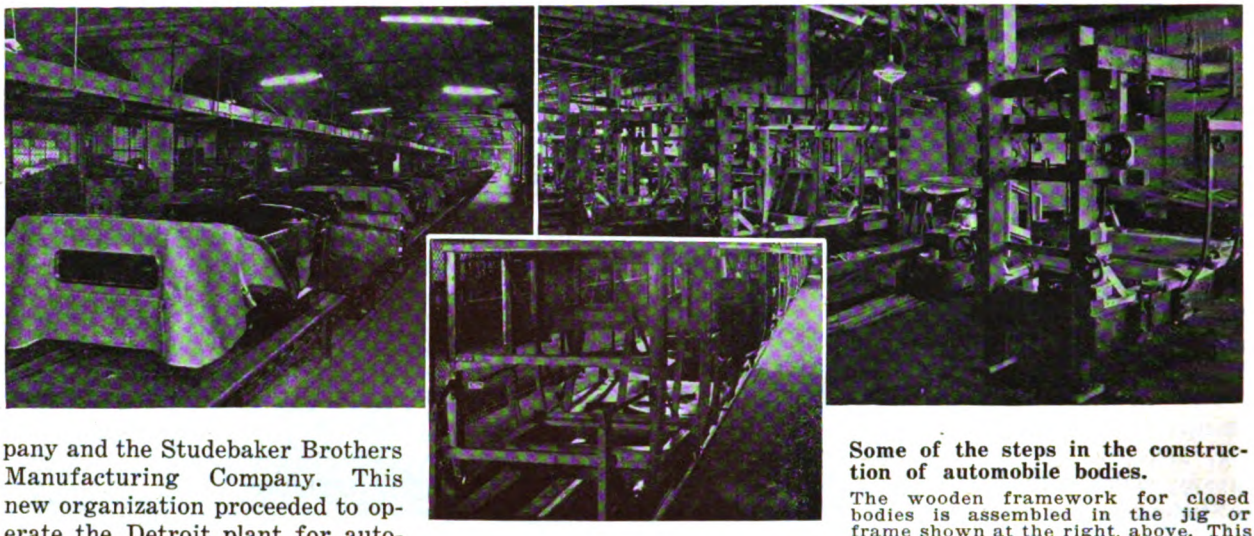
The Studebaker Corporation, organized in 1911, was the consolidation of this Detroit com-

Automobile factories are one of our best examples of specialized production, as shown here.

It was early found, that if mass production was to be feasible, some mechanical method of getting the work to the machine and away from it was necessary. It would require a small army of men to handle the material which the conveyors carry smoothly, and always to the proper destination. The upper illustration shows motors undergoing block tests. The illustration below shows a battery of gear-cutting machines.



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Some of the steps in the construction of automobile bodies.

The wooden framework for closed bodies is assembled in the jig or frame shown at the right, above. This holds the parts in perfect alignment while they are fastened and glued together so that the upholstery and trimmings may be cut beforehand to fit. Conveyors carry the frames away as shown in the lower illustration and as they travel along they are painted and the fittings and finally the upholstering attached, as is shown in the illustration at the left. Here the space overhead is used by a belt conveyor for handling other material.

pany and the Studebaker Brothers Manufacturing Company. This new organization proceeded to operate the Detroit plant for automobile production and the South Bend plant for horse-drawn vehicle production. The horse-drawn vehicle business was disposed of in 1919 and 1920 and at present the corporation confines itself to the manufacture of passenger-car automobiles only.

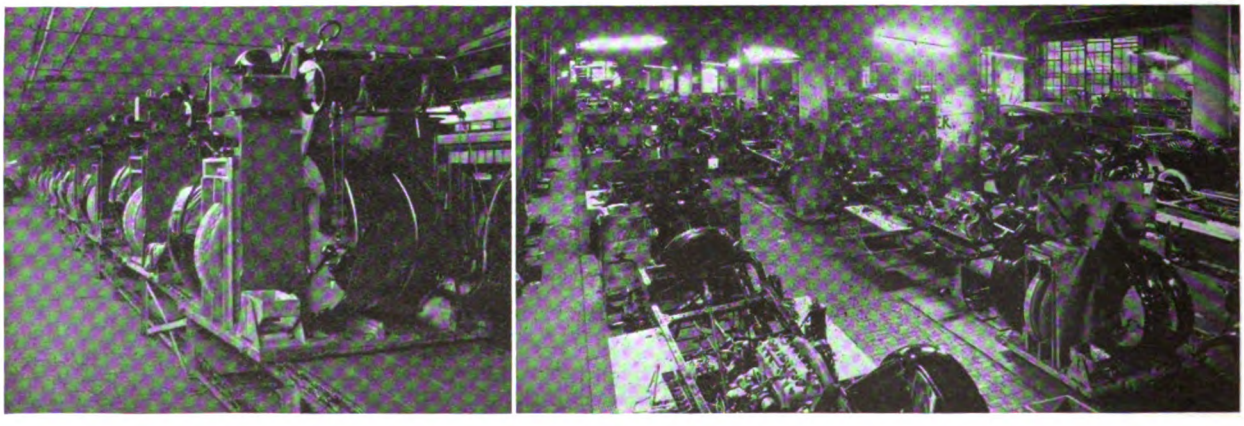
During 1922 the company sold over 110,000 cars, or an average operating capacity of about 430 cars per day. Plant extensions were completed in 1922 which increased the plant capacity to approximately 600 cars per day, or over 150,000 annually. The plant and property investment is over $45,000,000 and the company employed during the past year an average of 17,663 workers, or about 4,600 more than the previous year. An evidence of the growth of this concern as well as the industry is shown in the fact that about half of the floor space and about 75 per cent of the machinery and tool equipment has been added within the past six years. In addition, older buildings have been modernized as far as possible by the addition of new equipment and methods.

Of particular interest are the special plans used by Studebaker in its relations with employees. In spite of the large increase in the number of employees, approximately two-thirds receive anniversary checks denoting a period of service longer than one year. Also, over one-third of the factory employees receive vacations with pay, which show that they have been employees for more than two years. Also, over 3,000 employees are purchasing or own stock in the Studebaker Corporation.

Another outgrowth of the automobile industry has been extensive improvements in manufacturing methods, especially along the lines of specialization of machines and tools, many of them automatic or semi-automatic, often to perform only a single operation. The result has been intensive production of interchangeable parts. Also the industry is an extensive user of conveyors both for manufacturing and assembly. The benefits of these developments have been shared by many other industries.

These illustrate two of the steps in the final assembly of the car.

Wheels, tank, fenders, headlights and the other miscellaneous small parts of a car are put upon a stock rack in the stock room, as shown in the illustration at the left. Each rack contains the parts for one car. The racks are carried on conveyors to the assembly lines, as shown in the illustration at the right, and alternate with the chassis on the assembly conveyor. The parts are taken as needed from this stock rack and assembled on the car. The conveyor moves forward so as to bring the car to the different assemblers in succession, each specializing on placing a specific part on the car.



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BESIDES TELLING just how to test alternating-current motors, this article shows what is to be gained by such tests. Such tests will detect loss of power by defective equipment, misapplied equipment and low power factor. They will show up the faults of obsolete equipment. They will give the accounting department a definite basis on which to distribute costs. Tests should be made when new machinery is being installed and when additions or subtractions are made in group drives.

Directions for

Making Motor Tests

And Some Reasons Why They Should Be Made Regularly and at Certain Times

By J. ELMER HOUSLEY

Electrical Engineer, Aluminum Ore Company, East St. Louis, Ill.

IN THE industrial plant, the necessity of motor testing has been more and more recognized during the past few years and should now become of still greater importance under the spur of increasing needs for economy. The insistent demand of central stations for better power factor conditions associated with industrial loads requires an intelligent study of the duty cycles of motor drives and this study assumes equal importance in connection with an isolated generating station supplying an industrial load. The capacity and voltage regulation of the generators is greatly impaired by low power factors to say nothing of the overburdening of the cables, switches and transformers with excessive wattless current. Here the economic loss occurs in the form of excessive demand charges or in the expense of apparatus to correct the low power factor and poor voltage regulation.



Fig. 1 — Instruments connected ready to make a motor test.
This shows a graphic wattmeter, an ammeter and a voltmeter connected up with current transformers for testing an alternating-current motor. The ammeter and voltmeter have been tipped on their sides only to show them better while the photograph is being taken.

Motor testing is essential when additions or subtractions are made on a group drive in order to see that the driving motor is not overloaded or underloaded to a serious degree. In centrifugal-pumping operations it is essential that all installations be tested thoroughly to see that the duty cycle is economical. One investigation of a pumping installation resulted in a 100-hp. motor being replaced by a 40-hp. motor as actual operating conditions showed that the 100-hp. unit carried full load only half the time. Another pump was installed having a slightly lower discharge head and smaller capacity and driven by a 40-hp. motor which operated at a point near full load continuously. Many water-pumping systems having a variable demand can be handled similarly by the installation of moderate storage facilities. Many instances have been found where men in the operating departments run two pumps in parallel thinking they will secure double output from the pumps. Usually the extra pump is designed only as a spare and a test of the single and double units will show that the output is increased only 5 per cent or 10 per cent while the motor load is increased 60 per cent to 75 per cent. Many other studies of the motor drives in an industrial plant will yield interesting and profitable data concerning the economical operation of production machinery affecting both the quality and speed of production.

One important function of motor testing enters in the selection of motors for new applications. While very reliable data are furnished by the equipment manufacturers, owing to varying conditions it is always best to rely on individual data ob-

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tained first-hand. This is particularly true where many duplications of drives occur and the losses due to improper selection of motors are multiplied. Accurate motor tests are essential in choosing between direct-current motors and alternating-current slip-ring motors for variable-speed drives. The measurements of load variations may be used in determining whether to use armature control or field control or a combination of the two, and in selecting the proper slip-ring resistance. In the application of 50-deg. C. temperature rise motors, tests are indispensable owing to the fact that no allowance is made in the motor for temporary overloads which are likely to be encountered on many motor drives as variations in products are encountered or as the mechanical conditions of the driven machinery change. These are points which are liable to be overlooked.

The true measure of a plant's efficiency in the last analysis becomes the cost per unit of production and any variation in costs showing an upward tendency must be traced to some particular department where it then becomes necessary to make a detailed investigation. Here the motor test becomes very important. From the data obtained by a test the machines running under abnormal conditions may be spotted. In this way it is possible to find the motors that have broken-down rotors, or are overloaded from the poor mechanical condition of the drive or those which are supplied by a circuit which is overloaded and gives an excessive voltage drop, and so on. In the light of the knowledge obtained steps may be taken to bring conditions back to normal or even to improve previous practice.

Much test data concerning new methods in production must be obtained in order that the cost department may report on all changes in methods relative to the increase or decrease in costs resulting from such changes. Special reports are usually made to the cost department covering all data as to power consumed, quantities of work handled and other information necessary for a comparison with any other method of accomplishing the same result. Motor tests of old equipment may be compared with tests obtained upon new types of equipment and a program for scrapping obsolete equipment may be based on such comparative tests which prove the economic necessity for the change. The weeding out of obsolete mechanical drives involves consideration of both the electrical and the mechanical forces. In many plants time-study tests are essential to maintenance of a given schedule or for improvement of output and not infrequently this data should be supplemented by motor and circuit tests. These often confirm time studies or themselves may indicate the necessity of closer supervision over certain production processes.

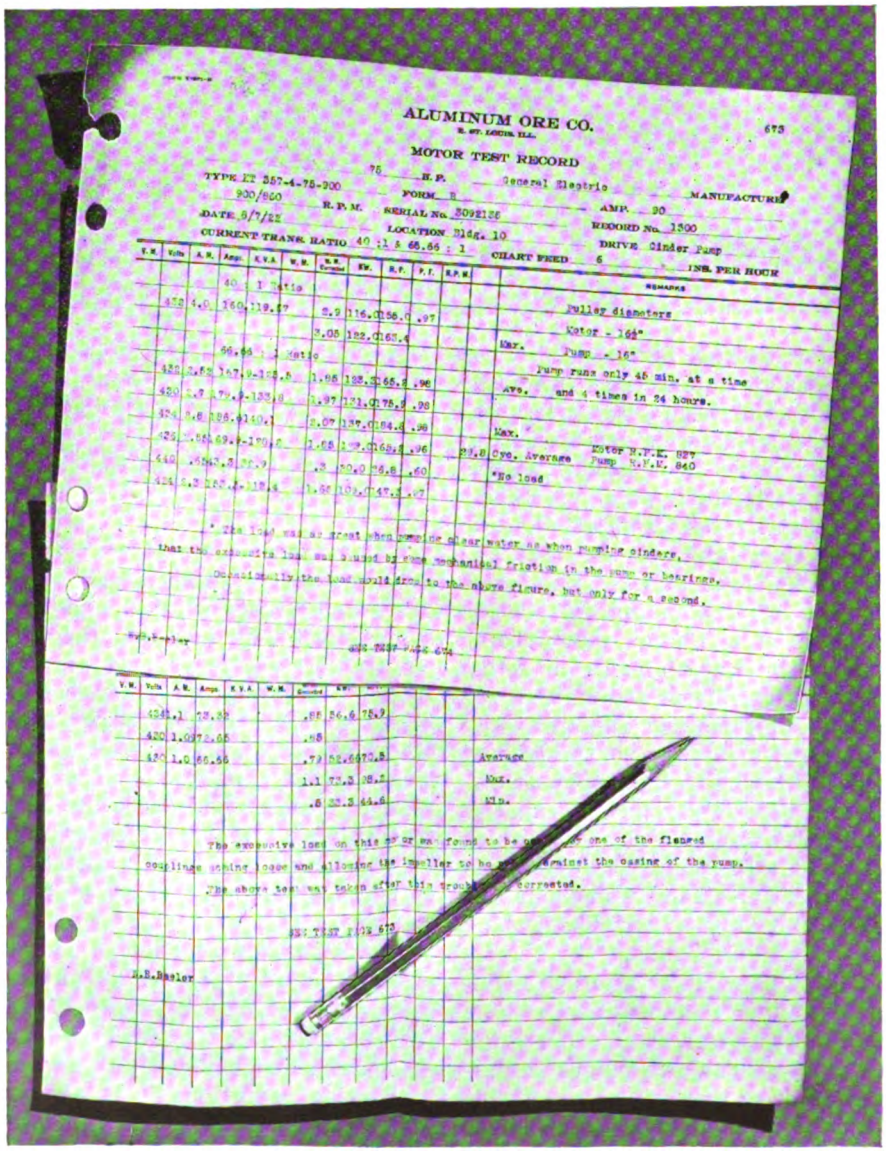


Fig. 2—Forms for recording data taken on a motor test.

These sheets measure 9¼x12 in. and they are filed according to the test number in a loose-leaf binder. The test number is written in the upper right-hand corner. Two important records kept by these forms are the original meter readings and the current-transformer ratio. Sheet 673, shown at the top of this illustration, records a test made on a pump motor which was overheating. The test showed that the 75-hp. motor was carrying over 200 per cent load. The trouble was found to be a defective coupling. After this was replaced the motor ran at an average load of 70 hp. as shown on sheet 674 (the lower sheet). The charts in Fig. 6 were taken on these tests.

Why Not a Physical Testing Laboratory?

The consideration of production studies brings us into the study of the quality and quantity of production. Here motor testing indicates the need of a physical laboratory consisting of mechanical, chemical, metallurgical engineers, or engineers of such other branches as the material produced would require. In such a case the electrical engineers should co-operate with the staff of the physical laboratory in making tests upon production apparatus. It appears that such a method would react towards maintaining a uniform quality of product and insure the maximum output of every unit in the plant. Undoubtedly the greatest benefit of this system would be derived by a very large establishment. However, in the smaller plants a similar method may be followed by combining several of these functions in a few individuals. This

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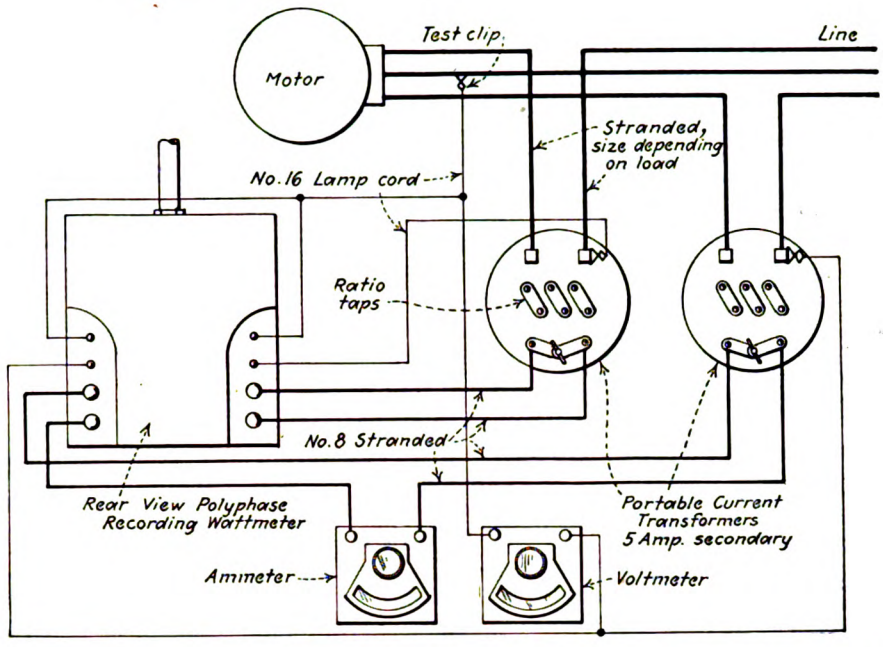


Fig. 4—Connections for making a test on an alternating-current motor.

The current leads and the potential leads attached to the same phase of the circuit must go to the same element of the wattmeter.

system has only been approximated in the writer's experience but the results obtained in a few instances where co-ordinated tests were made indicated great possibilities for the development of some sort of a physical laboratory for making periodic tests on every production unit.

Influence of Periodic Testing on Plant Maintenance

Wherever possible a periodic check of the kilowatt load of each motor in service should be made. By this plan irregularities in the operation of equipment may be discovered before serious consequences are experienced. Quite often centrifugal pumps become unbalanced creating a heavy thrust to one side of the pump and increasing the motor load to a dangerous point. The same condition is often found in the bearings of very heavy machinery. A seasonal variation of load is sometimes encountered on machinery in exposed locations. During the winter months a motor test will sometimes indicate a dangerous overload condition while the summer load is well within the capacity of the motor. The value of a test of this nature is that changes may be made in the nature of lubricant used which will reduce the load to a point within the capacity of the motor and show an appreciable saving in the power used.

Routine tests should always be supplemented by the observation of the oilers or department operators concerning any unusual temperature rise of the stator or bearings. Upon receipt of a report indicating a distressed motor an emergency test should be made immediately to ascertain whether the trouble is in the motor or in the mechanical equipment. If the trouble is mechanical a load test is essential after the mechanical repairs are completed. Many instances have been noted where several motors in a group would be reported as running hot which indicated without necessity of a motor test that a feeder circuit was operating single-phase. Sometimes, however, a single-phase condition like this will not be discovered until a routine motor test is made because if the motors are large and not heavily loaded and all motors on one circuit are shut down at one time no indication of distress will be evident.

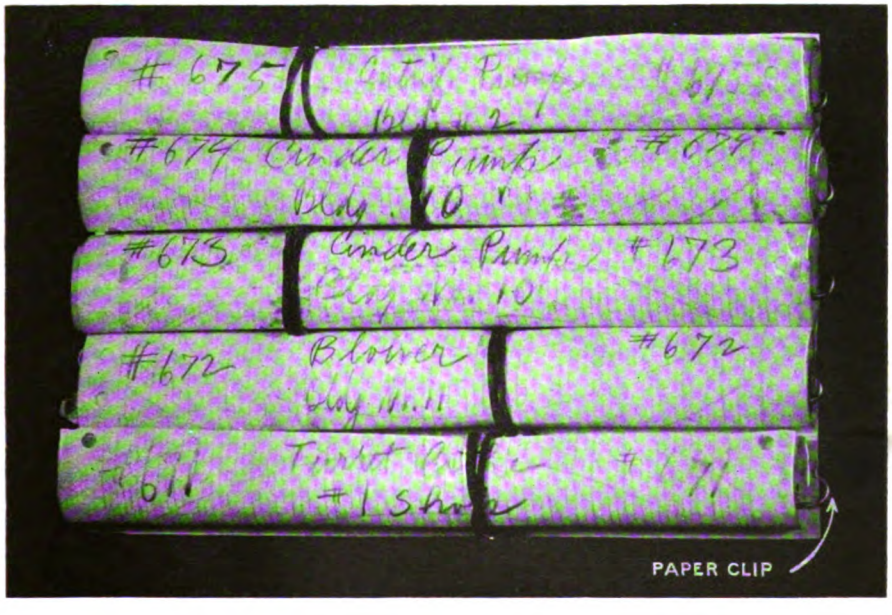


Fig. 3—Strip charts clipped to a card for handy filing.

Testing Equipment Required

For the industrial plant having 10,000 hp. or less in connected load and using alternating current the following list of equipment constitutes the minimum for satisfactory motor or circuit testing:

Two portable current transformers, range 25 to 100 amp. primary, 5 amp. secondary.
Two portable current transformers, range 200 to 1000 amp. primary, 5 amp. secondary. To be of the through type of single-turn primary.
One voltmeter, indicating, 0/150, 0/300, 0/600-volt scales.
One ammeter, indicating, 0/5-amp. scale.
One wattmeter, polyphase, recording, strip-chart type with device to change speed of chart from inches per hour to inches per minute.

The strip-chart meter has been adopted almost universally for motor tests because of the legibility of the record and the ability to get satisfactory records of any type of intermittent load by varying the chart speed so as not to overlap the fluctuations of the pen.

For ordinary load tests on motors, two observers are required. One man cannot make a simultaneous reading of the wattmeter, ammeter and voltmeter. During a test the voltmeter and ammeter readings should be noted on the strip chart at intervals so that variations in the wattmeter record are noted in connection with voltage and amperage at that instant. Every chart should have indicated on it the date of test, the name of the drive tested, the cur-

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rent-transformer ratio and the times of beginning and ending the test. The value of a test chart for future reference is often lost through the omission of this data from the chart. It is nearly always desirable to have a calibration curve for the wattmeter for correcting the actual readings before writing up the tests. Changes should not be made in the zero setting of the wattmeter during the interval between calibration tests.

How to Keep Records of Tests

It is desirable to write up all tests on a form sheet in order to prevent the omission of any necessary data. A good form for this purpose is shown in Fig. 2. This record should include space for the original readings of the meter scale as well as spaces for the actual quantities after the readings have been corrected and multiplied by the instrument ratio. Space should be provided for any desired calculated data such as kva. and power factor and also speed of the motor, frequency, etc. Ample space should be allowed for remarks concerning conditions under which the tests were made, variations in load and observations of pressures, quantities of material handled, speed of belted shafts and observations covering the mechanical condition of drives, the temperature of the surrounding air and of the motor.

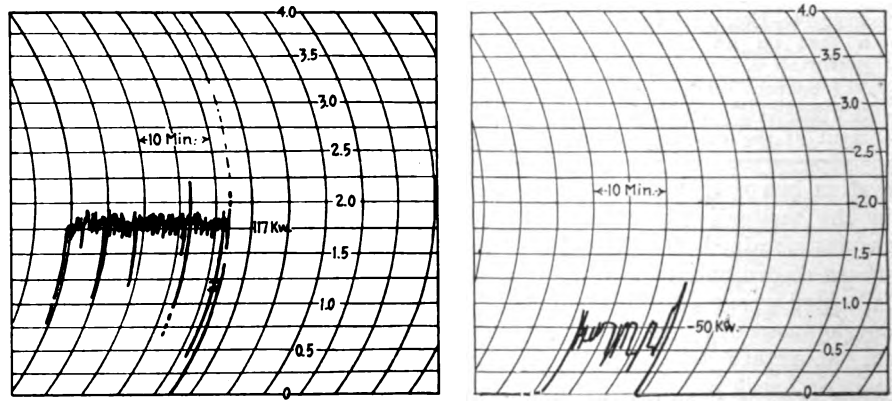


Fig. 6—Graphic meter charts before and after removing trouble on pump.
In Fig. 2 are complete records of the tests during which these charts were taken. The charts show not only the magnitude of the load but also how it varies from time to time.

Every effort should be made to secure sufficient data for properly interpreting the results of the test at any future date. Insufficient data is a common fault of a majority of motor tests. All data which is taken in note books should be transcribed to the form sheet on the day of the test as any omission of data may be more easily supplied while the conditions of the test are still well in mind. Where an index is maintained covering each motor in the plant and an index for each drive, it is desirable to note the average load, date of test, and page number of the form sheet data on the corresponding motor card and drive card. The form sheets called the "Motor Test Record" should be kept in a binder and each page numbered consecutively. Each strip chart corresponding to a record sheet should be given the same number. These strip charts may be filed for future reference in a convenient manner by rolling them up and fastening each end to a 4-in. x 6-in. index card by means of a paper clip as shown in Fig. 3. About five of these charts can be attached to each card and the chart number should be written on the outside. In this manner a large number of strip charts may be fastened on a small card and filed in a regular card-index drawer. The charts are then always immediately at hand for reference.

Connecting the Instruments for Motor Tests

In making tests on three-phase motors using the standard three-phase recording wattmeter, it is necessary to insert two current transformers in the leads supplying current to the motor. Voltage connections, however, must be made to each of the three leads in three-phase testing. The voltage or potential lead from the motor lead which does not have a current transformer, is a common lead between the two potential coils in the wattmeter. In making wattmeter connections it must be remembered that each potential coil must be supplied from the lead which *(Continued on page 371)*

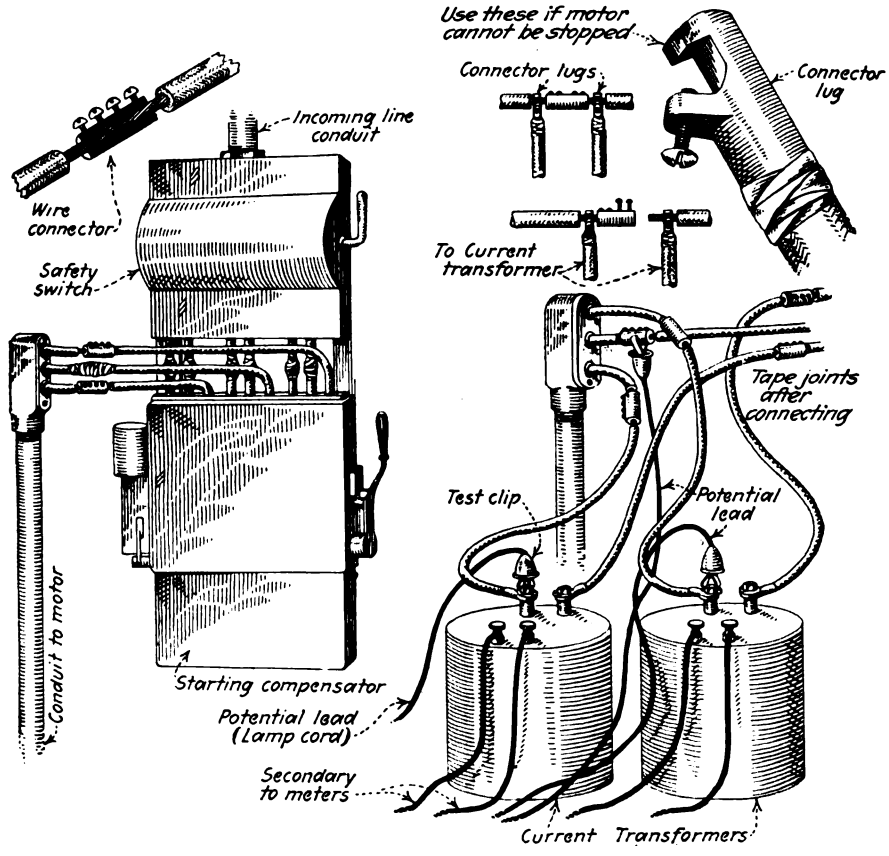
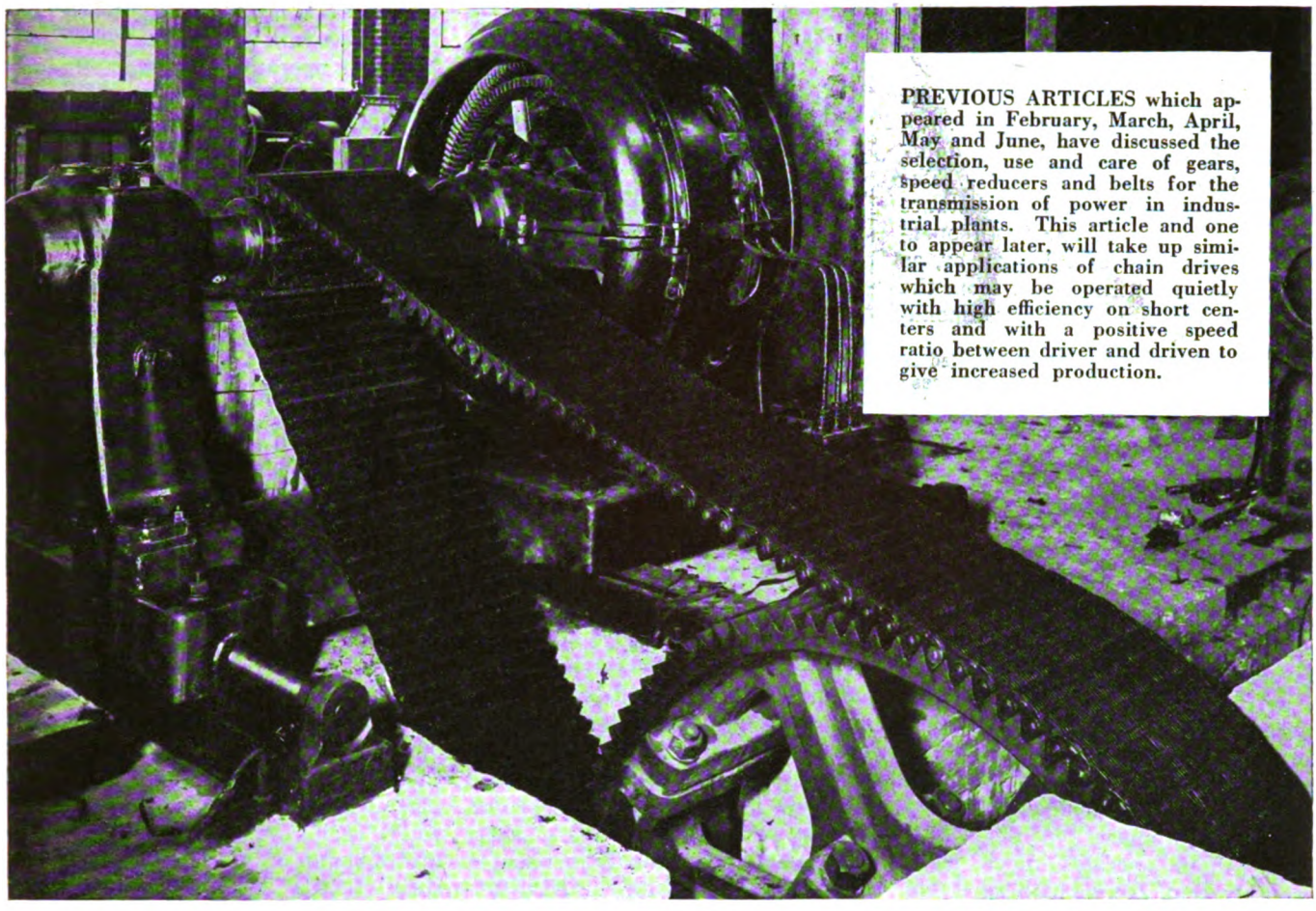


Fig 5—This shows how the leads are connected on a motor test.
When the motor was installed brass connectors were inserted in the leads between compensator and motor. These are opened and the primary of the current transformers is connected in each outside line. If the motor cannot be stopped for making connections, the current transformers may be connected in as shown in the upper right-hand corner. The connecting lugs on the transformer leads are attached on each side of the brass connectors after which these connectors are opened.

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PREVIOUS ARTICLES which appeared in February, March, April, May and June, have discussed the selection, use and care of gears, speed reducers and belts for the transmission of power in industrial plants. This article and one to appear later, will take up similar applications of chain drives which may be operated quietly with high efficiency on short centers and with a positive speed ratio between driver and driven to give increased production.

This 300-hp. motor is connected by chain drive to a lineshaft operating a group of rubber mills.

Points to Consider in Using Various

Types and Kinds of Chain Drives

To Provide a Short-Center Connection With the Lowest Possible Power Loss

By FRANK E. GOODING
Associate Editor, Industrial Engineer

CHAIN DRIVES combine many of the advantages and characteristics of belts and gears, both of which have been discussed in previous articles in INDUSTRIAL ENGINEER. Chain drives are used in practically all industries that use power. Their principal advantage lies in their high efficiency; a chain drive will transmit to the driven shaft over 98 per cent of the power delivered to it by the driver. There can be no slip or loss of power nor is there any back lash or chatter. As a silent chain wears it does not lose its efficiency, as the chain gradually mounts the teeth of the sprocket to take up the wear in the joints.

Other advantages to be derived are that chain drives can be operated on short centers, thus saving space and at the same time permit of a much greater flexibility of centers than is possible with a gear drive and they will operate under conditions that interfere with the effective operation of belts, such as heat, cold, wet or greasy surroundings. Next to a belt silent chain drives are the most quiet in operation of any method of power transmission, with the exception, of course, of a direct connection. One of the main advantages is a fixed speed ratio between the driver and the driven sprockets such as is otherwise obtained only through gearing.

With chain drives it is usually possible to operate without idlers. However, they are sometimes used to lead the chain around obstructions or when there is considerable distance between centers. Properly designed and lubricated chain drives operate quietly, but if neglected or if some of the limitations, as speed, size of sprocket, revolutions per minute, pitch and other factors which will be mentioned later, are exceeded life and quiet operation are sacrificed accordingly.

In general, there are three kinds of chains: block, roller and what are known as silent chains. Block and roller chains are most often used for connecting up two or more shafts of a machine to give a positive ratio between them. Block chains are seldom used for power transmission of over a few horsepower, but are fre-

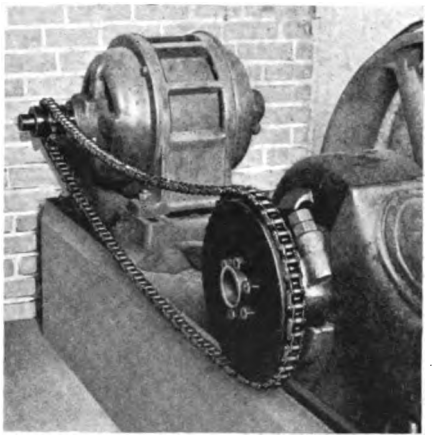
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quently used on small machines, like bicycles and other light devices. Well-designed roller chains are used commonly up to about 25 to 30 hp. and in some cases much higher.

Block chains consist of a solid link joined by a pin and side plates. The pitch of a block chain is the distance from the center of one tooth opening to the center of the next, or, as it is most often measured, from the center of one pin to the corresponding pin in the next link.

Roller chains consist of links or plates fastened together by pins fitted through rollers, although some cheap grades are fastened by pins only and are not adapted to high speed or heavy service. In most roller chains the links are of equal length and so the pitch, the distance from pin to pin, is approximately one-half of that of block chains of corresponding size of links which have twice the pitch. In this way a sprocket for a roller chain has twice as many teeth as a sprocket for a block chain of twice the pitch. The corresponding pitch of the three types of chain are made clear by the sketches reproduced on page 337. Roller chain operates much more smoothly than block chain as it fits over a larger number of teeth and may be used at a higher speed.

Roller chains are sometimes run at speeds of 2,000 ft. per min., but speeds of 1,000 ft. per min. or less are much more satisfactory. Block chains are adapted to lower speeds, 700 to 800 ft. per min. or less. If the speed and load are not fixed qualities it is advisable to keep the speed high and the chain pull low,



A motor connected by roller chain to an air compressor, for direct drive.

Air compressor drives are hard on chains. Here, however, the impulse shocks are taken care of partially by the momentum of the flywheel. The construction of a roller chain can easily be seen. It is made up of a series of inside and outside links fastened together by pins on which loose rollers are fitted.

and it should be remembered that high speeds are more destructive to chains of large pitch than to those of small pitch as will be explained elsewhere in this article. Therefore, the use of chains having a short pitch and a proportionate increase in width is recommended. A disadvantage of both of these types of chain lies in the limitations on increasing the width so as to add to capacity.

Construction and Some of the Applications of Silent Chains

Silent chains are made up of special types of pins, connecting links so designed as to provide on the chain a tooth which fits into the tooth on the sprocket. They are in reality flexible racks; when straight, as in between sprockets, a chain acts as a rack and when passing over a sprocket acts as a reflex gear. It is similar in effect to two gears with about half their teeth in mesh except that the load is divided among them instead of being all on one tooth, as is the case with gears. The construction and operation of silent chains is shown in some of the accompanying illustrations. The pitch of silent chains is the distance between the centers of pins in a chain. Sprockets do not have pitch dimensions, as do gears, but are designed to take a certain pitch of chain.

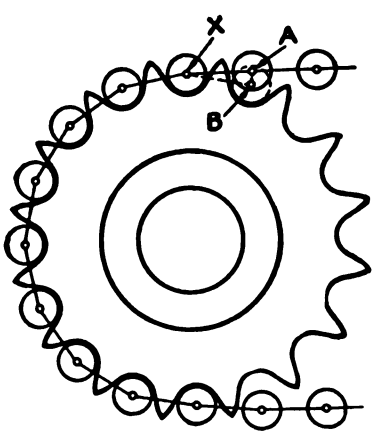
Silent chains are made in varying capacities from fractional horsepower to one large installation of 5,000 hp. They may be constructed in any width but for ease in handling are seldom made wider than eight times the pitch. In case a wider chain is necessary, two chains are used or else a chain of a larger pitch.

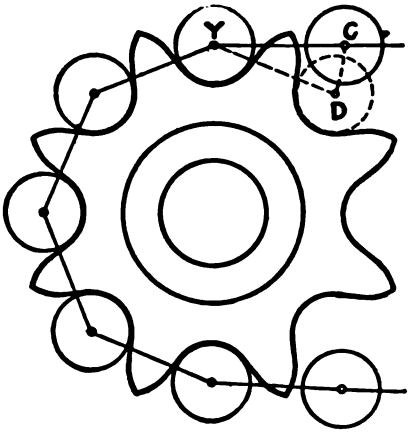
Originally, chain drives were installed where gears could not be used, except in trains with heavy friction loss, where belts gave trouble, or where it was desired to give a positive ratio between machine elements. At present, in addition to these, many other installations are being made, particularly on machines in continuous operation, where each revolution means a definite amount of production, as with some textile machines, automatic punch or stamping presses, screw machines and numerous other machine tools.

With chain drives, every revolution of the driver means a definite number of revolutions of the driven wheel (according to the speed reduction ratio) and this ratio is always maintained until the chain or sprockets are worn out. Belts, when operated under the best conditions, give a low slippage loss, but if they are neglected and allowed to loosen up the slip is more. This loss is not noticed ordinarily as it is a gradual increment. In actual instances textile mills have increased output as high as 10 per cent and the output of machine tools has been increased

This is the explanation of why pitch and revolutions per minute are the limiting factors in chain drives.

As stated in the text, the pitch and the revolutions per minute of the sprocket are of more importance in determining chain-drive limitations than chain speed in feet per minute. As shown in these drawings one sprocket has ten teeth and the other twenty, and the pitch of the chain on the wheel with ten sprockets is twice that of the other. If the revolutions per minute are the same in both cases, the point **A** will reach point **B** in the same length of time as point **C** will reach its point of rest, **D**. However, the distance **C** to **D** is twice that of **A** to **C** and so the larger chain will strike its sprocket at twice the velocity of the one with a smaller pitch. As the force of the blow increases with the square of the velocity, the large chain "hammers" the sprockets four times as hard as the small chain, although both are traveling at the same speed in ft. per min. If the diameters of the sprockets are increased, without increasing the revolutions per minute, the force of the blows does not increase correspondingly, although the speed in feet per minute and the horsepower capacity have both been thereby increased.





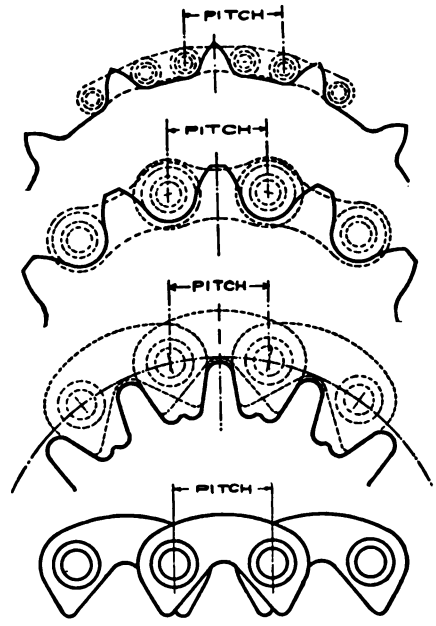
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up to 18 per cent, merely by a change in drive.

Factors Governing the Installation of Chain Drives

In installing chain drives the governing factors are the revolutions per minute, the horsepower, and the minimum diameter necessary on the sprocket wheel, which limits the number of teeth. Chains are made of steel, tempered and slightly annealed to give toughness. However, the chains strike a series of hammer blows against the sprockets at each revolution and this will eventually affect the steel, if the blow is too hard. The force of this blow increases with the revolutions per minute (instead of the speed) and with increased pitch. For this reason chains of small pitch should be used with high speed as they do not hit as violent a blow. Why this is so is explained in the caption under the drawing reproduced on page 336. It is often possible to increase the diameter of the sprockets and so decrease the necessary revolutions per minute to get the same power transmitted as the power is a function of the speed of the chain. On properly designed chain-drive installations these hammer blows do not affect the life or operating conditions as they may if the drive is improperly designed.

What relationship should exist between chain pitch, revolutions per minute and horsepower can best be obtained from the manufacturer of the particular chain to be installed as they vary somewhat with each different type of chain drive manufactured. In general, however, it is not advisable to use a sprocket with less than 13 teeth and preferably with at least 15 or 17, or more if possible, depending on the pitch. Even with the smallest pitch of silent chains, 35 to 45 teeth in the sprocket are desirable. Also, it is desirable to have an even number of links in the chain and an odd number of teeth in the sprocket as such a condition gives more uniform wear because it prevents the same teeth and links from making regular, repeated contacts. If the center distance is absolutely fixed it is sometimes necessary to use a special connecting link which is called a "hunting link" and is so designed that three links take the place of four and makes the number of links in the chain odd. An odd number of links or pitches in a roller chain are connected up by what is known as an "offset" link.



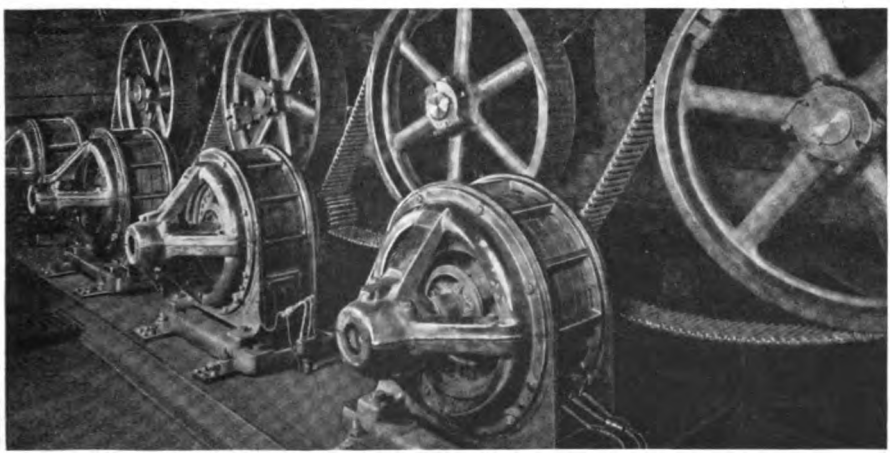
How the pitch is measured on block, roller and silent chain drives.

These three chains are all drawn to scale so that they are the same pitch. The block chain is at the top, roller next, and silent chains in the two lower illustrations. It may be seen from this why block chain sprockets have only half the teeth and also why the chains are much smaller for the same pitch. It should be remembered that chain sprockets have no pitch line or measurement as is used in connection with gears. On the silent chains what might be called the pitch circle is outside the end of the teeth. How to order sprockets will be told in the next article.

The width of sprockets should be at least 1.2 times the pitch. Ordinarily, it is not desirable to drive silent chains at over 1,200 to 1,600 ft. per min. Many installations are working satisfactorily at much greater speed, but at a sacrifice of quiet operation, short life and high maintenance in some cases. Installations above this recommended speed or having any other unusual features, should be referred to the manufacturer's engineering department for approval or special modifications for that particular installation. It is always advisable to avoid vertical drives, especially with the small sprockets below as a loose chain or any wear or elongation of the chain will cause it to ride high and wear off the tops of the sprocket teeth in the same way that they do when the links are elongated, as shown in the sketch reproduced on page 338. If too much slack is allowed the chain will jump the teeth.

The effect is not so bad if the large sprocket is used below but a horizontal drive is most satisfactory. A slack of about ¼ in. to ½ in. drop per foot of span is recommended. It is almost essential on vertical drives to provide some means of take-up for adjusting wear and stretch, and it is usually desirable on horizontal drives. However, chain drives, except on vertical drives, operate better if one side is slack. The best method of taking up slack is by an adjustable base or mounting plate, although idlers may be used. However, in case an idler is used it should be as large as possible and never below the minimum number of teeth recommended for that pitch of chain. The idler should have teeth the same as any other sprocket and be used on the inside of the slack side of the chain. In cases of necessity, such as getting around obstructing shafts, rawhide or fiber idlers without teeth are sometimes used on the back of chains but this is to be avoided whenever possible as it gives a reflex bending to the chain and adds that much more friction to the drive.

A chain needs a side clearance

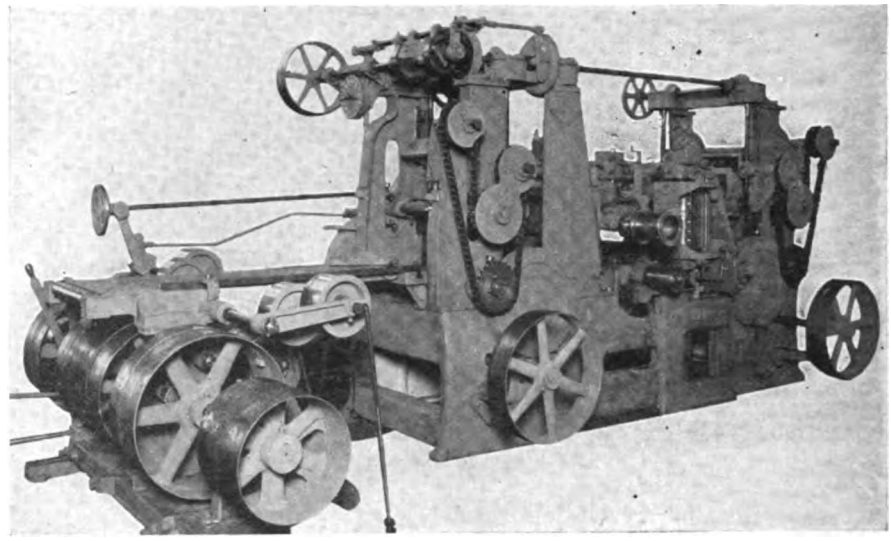


Four chain drives, each operated by an individual motor, are installed here on oil presses at a linseed oil plant.

This is an excellent illustration of a compact arrangement. Other types of drives would require that the motor be several times as far from the driven shaft. This would increase the distance between the presses.

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Here roller chains are used to connect feeds and cutting tools.
Where it is desired to have a positive ratio between two or more working elements on a machine, gears or chains must be used to connect them up. This "sizer" will take a timber 16 in. thick by 20 in. wide.



equal to the pitch to prevent rubbing and wearing on the sides. A silent chain will stay on the sprockets without any guide if the sprockets are parallel and properly aligned. However, the manufacturer of each type of chain provides some method of holding it on the sprocket as a precaution in case a sprocket should slip. For example, block and roller chains fit around the teeth of the sprocket and so can be used on equipment where the alignment varies, as in automobile drives, due to the swaying of the body and rough roads.

One method of holding a silent chain in position is by a flange or shroud. These are made from steel plates fastened to the side of the sprocket or, in some cases, of wire crimped to fit into the teeth and fastened around the edge of the wheel. For these, the wheel must be wide enough to take the crimped wire for the flange. This is easy to apply and does not interfere with the cutting of the teeth. Other methods used are to provide solid links in the chain which fit into a groove in the sprockets or in some cases over the ends of the teeth on the outside of the sprocket. When a chain shows signs of wearing either the flange, the groove in the sprocket or the solid links fitting into the chain, it indicates that the sprockets are out of alignment.

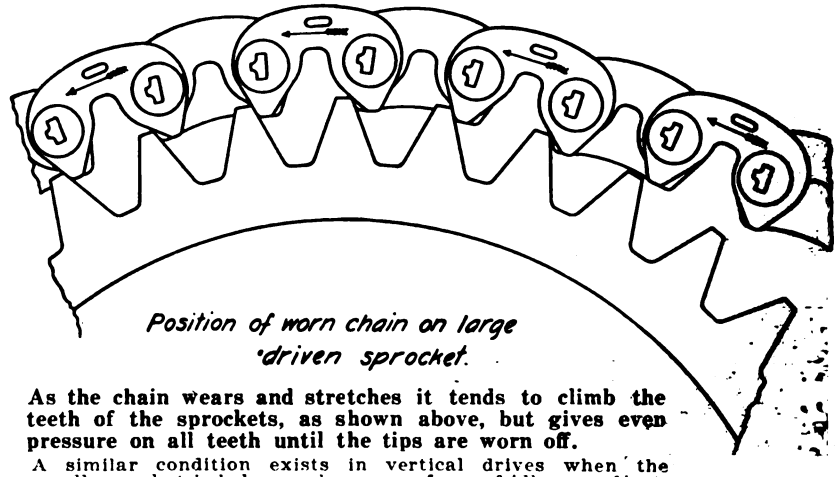
How the Wear Affects Chains and Sprocket Teeth

As silent chains wear the pitch of the link lengthens from two causes: the very slight stretch of the link and the wearing of the connecting pins or the holes in which they fit. This causes silent chains to ride high on the teeth of the sprocket, as shown in the sketch at the right, which is exaggerated somewhat, and wear away the ends of the teeth. This elongation must not exceed ⅜ in. per ft. The chains, however, still exert an even pressure on all the teeth until the tips of the teeth are worn away so that the chain slips. This can be partially corrected by repinning the chain, that is, by using new pins and bushings slightly larger to compensate for the wear. This is best done by the manufacturer in his factory but may be done at the industrial plant over the Sunday shut-down if samples of worn links are first sent to the factory to get the proper size of pin or bushing. Two sample links should be sent which are taken, one from each side and about midway between the center and the edges of the silent chain and in the same row crosswise.

Ordinarily, a sprocket may be expected to outlast three new chains or one chain twice repinned. Chains and sprockets in excessively dusty locations, particularly around cement and ashes, wear more than ordinary. In the average industrial plant if a chain is taken care of, as will be explained later in this article, this wear due to foreign matter is of little consequence.

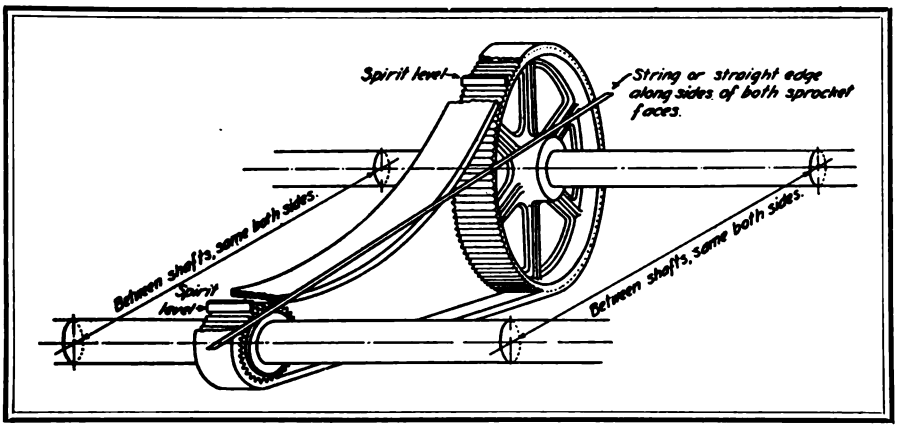
Block and roller chains stretch and lengthen the pitch in the same way as do silent chains. However, instead of exerting an even pressure on all the teeth, all the load is concentrated on one tooth with the others not touching the chain, or, if the wear is excessive the chain also makes contact with the back of a tooth. The sprocket teeth also wear near the base into a hook shape. This wear is increased if the tooth is of improper shape. With properly designed teeth the chain tends to ride higher as the pitch increases and so does not wear the tooth into a hook shape. Considerable effort has been made towards standardization of some sizes and shapes of block and roller chains and the sprockets and teeth so that the user may be more sure of getting the same size even if he should order from different manufacturers. Standard roller chains are made in the following pitches: ⅜-in., ½-in., ⅝-in., ¾-in., 1-in., 1¼-in., 1½-in., 1¾-in., 2-in., 2½-in. and 3-in.

The number of teeth in roller chain sprockets should be as large as is consistent with the conditions. A larger number of teeth reduces



As the chain wears and stretches it tends to climb the teeth of the sprockets, as shown above, but gives even pressure on all teeth until the tips are worn off.
A similar condition exists in vertical drives when the small sprocket is below, unless some form of idler or adjustment is used to maintain contact.

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One of the most important features of installing chain drives is to get the sprockets aligned and to have the lineshafts parallel.

A spirit level on the face of the teeth shows whether the sprockets and lineshaft are level. It is also necessary to check the distance between the shafts on both sides, as shown, to see if the shafts are parallel. The alignment may be checked with a string or a straight-edge stretched across the face of the sprockets as shown, and should be checked up frequently, as the sprockets may slip. Slip or misalignment may be seen by observing the guide links in the chain and the groove in the sprocket to see if they are worn equally on both sides, or by noticing the wear on the flanges and outside links of the chain. After trying the straight-edge in one position it is well to turn the larger sprocket a third of a revolution and again test, both as a check on the first test and also to determine whether the shafts are parallel. This method may be used when it is not practicable or is difficult to measure the distance between the shafts.

the noise, the wear of the chain on the sprockets, and the loss of energy from friction. The best results are obtained from sprockets having sixteen teeth or more. Eight- or nine-tooth sprockets will almost invariably ruin a roller chain, and those having ten or eleven teeth are only adapted for medium and slow speeds with other conditions favorable. The speed of the chain is not as important as the revolutions per minute and size of sprockets. It is better to use large sprockets and increase the speed of the chain than to use small sprockets for the same power transmission in order to secure a lower-speed chain.

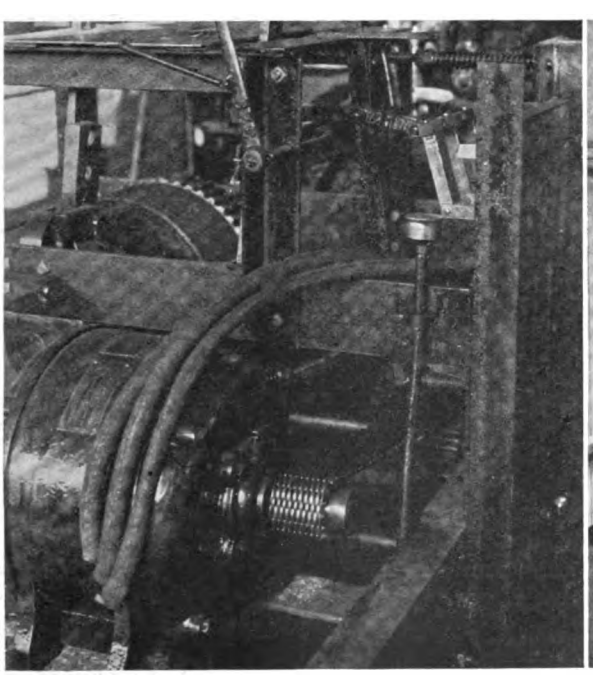
With larger sprockets the angular motion or friction between pins and bushings is reduced and the chain pull is less. The ratio between the driven and the driving sprocket should not be over 1 to 8 for block chains of the bicycle type nor over 1 to 5 for roller chains of ⅝-in. pitch or over. A center distance of thirty-five to forty times the pitch of a roller or block chain gives the best results. More center distance than this creates an excessive chain sag resulting in a centrifugal whip, which in time ruins a chain.

Some Methods of Lubricating the Different Chain Drives

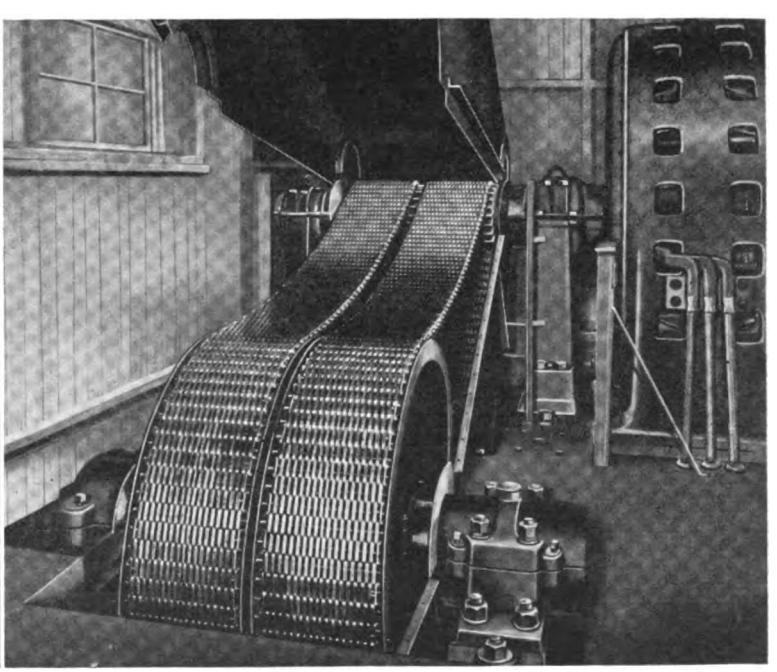
The manufacturers of block and roller chains and of most silent chain drives recommend that the chain run in an oil bath if under heavy load or in continuous operation. In one case, however, it is claimed that this is not necessary if the chain is frequently cleaned and regreased. The wear on chains comes on the pins, between the chain and the teeth; and in the side wear due to the rubbing of the sides of the links against each other in the constant bending and straightening out as the chain passes over the sprocket. One big advantage of the oil bath is that it lubricates in all these points. Grease is frequently used on block or roller chain and on some silent chains. In dusty locations chains should at least be encased, even if not running in oil. For the safety of operation and workmen it is well always to have chain drive enclosed.

Probably the easiest method of cleaning any form of chain is to remove it at least once a month, or more often in dusty locations, and souse it in kerosene. If more convenient, it may be cleaned by steam. In all cases it should be lubricated before using. Oil in the chain case should be (*Continued on page 372*)

Silent chain drive on a baler.
Here the motor is connected to a worm shaft which gives additional speed reduction.



This 750-hp. motor drives a lineshaft in a rubber mill.
The motor operates at 350 r.p.m. through a 21-tooth pinion sprocket which drives an 81-tooth split wheel at 82 r.p.m. The centers are 108½ in. with a chain of 2½-in. pitch.



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IN THIS ARTICLE Mr. Dudley shows that chord factor deals with the pitch or throw of the coil and whether it does or does not surround the whole of the mechanical pole and that distribution factor deals with the phase of the winding and the groups or bands per pair of poles into which each phase winding is distributed or arranged. He also shows that distribution factor is a measure of how effectively the turns in the winding are used. Mr. Dudley is the author of Connecting Induction Motors and is a well-known authority on this subject.



This is a Simple Explanation of

Distribution and Chord Factors

And the Uses That Are Made of Them in Winding Stators of Induction Motors

By A. M. DUDLEY

Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

IN A GENERATOR or motor the magnetic field which is set up is proportional to the *ampere turns* in the winding. That is to say, the magnetic field is influenced directly by the number of turns of wire surrounding the magnetic circuit and by the number of amperes of electrical current flowing in these turns. In the case of a direct-current machine where the field coils have the familiar form shown in Fig. 1, this is very easily calculated because the turns are all concentrated in a group and completely surround the mechanical pole structure in which they are setting up a magnetic field. Such a coil or field winding is called *concentrated.*

In the case of a *distributed* winding shown in Fig. 2, which is usually used on induction motors and other alternating-current motors, the case is not so simple. The effective ampere turns or magneto-motive force is not obtained directly by multiplying the number of turns by the amperes flowing, but must be modified by two factors called *chord factor* and *distribution factor.* The first of these deals with the *pitch* or *throw* of the coil, which means whether it does or does not surround the whole of the mechanical pole, and the second has to do with the *phase* of the winding—that is, whether it is single phase, two phase, or three phase —and in how many groups or bands per pair of poles each phase winding is distributed or arranged.

What is meant by *current bands* is groups of adjacent conductors in which the current is of the same phase and flowing in the same direction. This can be understood from consideration of Fig. 3, diagrams *A* to *F* inclusive, which represent a portion of a typical induction motor winding and the current conditions which exist in such a winding when variously connected for two phase or three phase, with standard connection or consequent-pole connection.

Diagram *A* shows twelve slots of the stator core of an induction motor and the twelve coils that lie therein. These coils have a throw of slots 1 and 7, which in this case is assumed to be full pitch. The portion of the winding shown covers 360 electrical degrees; that is, from the center of one north pole to the center of the next north pole. The coils as shown are unconnected, the terminal wires for the beginning and ending of each coil being brought out and marked *1b, 1e, 2b, 2e,* and so on.

In diagram *B* are represented the current conditions that would exist in the winding of diagram *A* if the coils were connected to form two

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pole-phase-groups of a single-phase winding. The top line marked Way Coils Are Connected is a schematic diagram showing the coil-to-coil connections and the group connections for such a connection. The small coil marked *1* represents the coil lying in slots No. 1 and No. 7 of diagram *A*, having the wire marked *1b* in diagram *A* brought out for a lead, *A*, and having the wire marked *1e* connected to *2b* on coil No. 2, and so on. In this manner coils 1 to 6 inclusive are connected in series to form a pole-phase-group, and coils 7 to 12 inclusive are connected in series to form a second pole-phase-group. These two groups are then properly connected to form an adjacent north and south pole in the winding. The next horizontal picture in diagram *B* marked Cross Section of Coils and Core shows the direction of the current in each slot and is shown as if a cross section of all coils were taken along the line *XY* shown in diagram *A*. Conductors in which current is assumed to be flowing away from the observer are marked *X* and conductors in which the current is assumed as flowing toward the observer are marked with a circle and dot in the center. The slots are marked 1 to 12 inclusive. A consideration of the currents in all twelve coils shows that they come in groups or bands of twelve conductors in one direction and then twelve in the opposite direction. Therefore, the current bands are as shown by the wide black lines at the bottom of diagram *B*, and also as shown there are two current bands per pair of poles. In Fig. 6, as discussed below, is shown the geometrical derivation for the distribution factor of such a winding.

Diagram *C* of Fig. 3 shows the corresponding conditions which would exist if the coils of diagram *A* were connected for two-phase, two-pole as schematically indicated at the top of diagram *C*. An examination of the *current bands* at the bottom of diagram *C* shows that there are four current bands per pair of poles. For convenience, in the current bands *A* phase current is shown by circles and *B* phase by squares. Fig. 4 shows how the distribution factor for such a connection is derived.

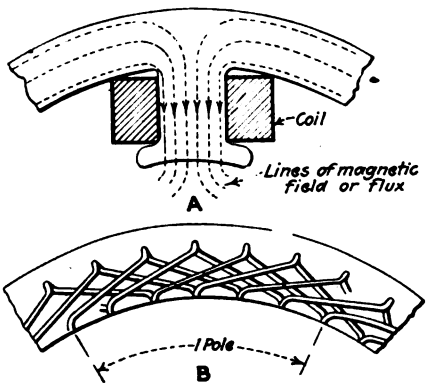


Fig. 1 — Direct-current machine showing concentrated field winding. Fig. 2 — Alternating-current machine showing distributed field winding.

Again, diagram *D* of Fig. 3 assumes that the coils of diagram *A* have been connected for two-phase, two-pole, but with a *consequent pole* arrangement; that is to say, with all pole-phase-groups, for example, connected to produce north poles and letting the south poles result from the magnetic flux finding its way back in between the north poles as best it can. There are only two current bands per pair of poles as shown at the bottom of diagram *D*. In this case current bands for the top coils in the slot alone are shown. The distribution factor of such a winding may be derived from Fig. 4, as explained below, and is the same as for the single-phase winding of diagram *B*. Such a connection might be found on the slow-speed connection of a two-speed winding.

Similarly, diagram *E* of Fig 3 shows the conditions if the coils of

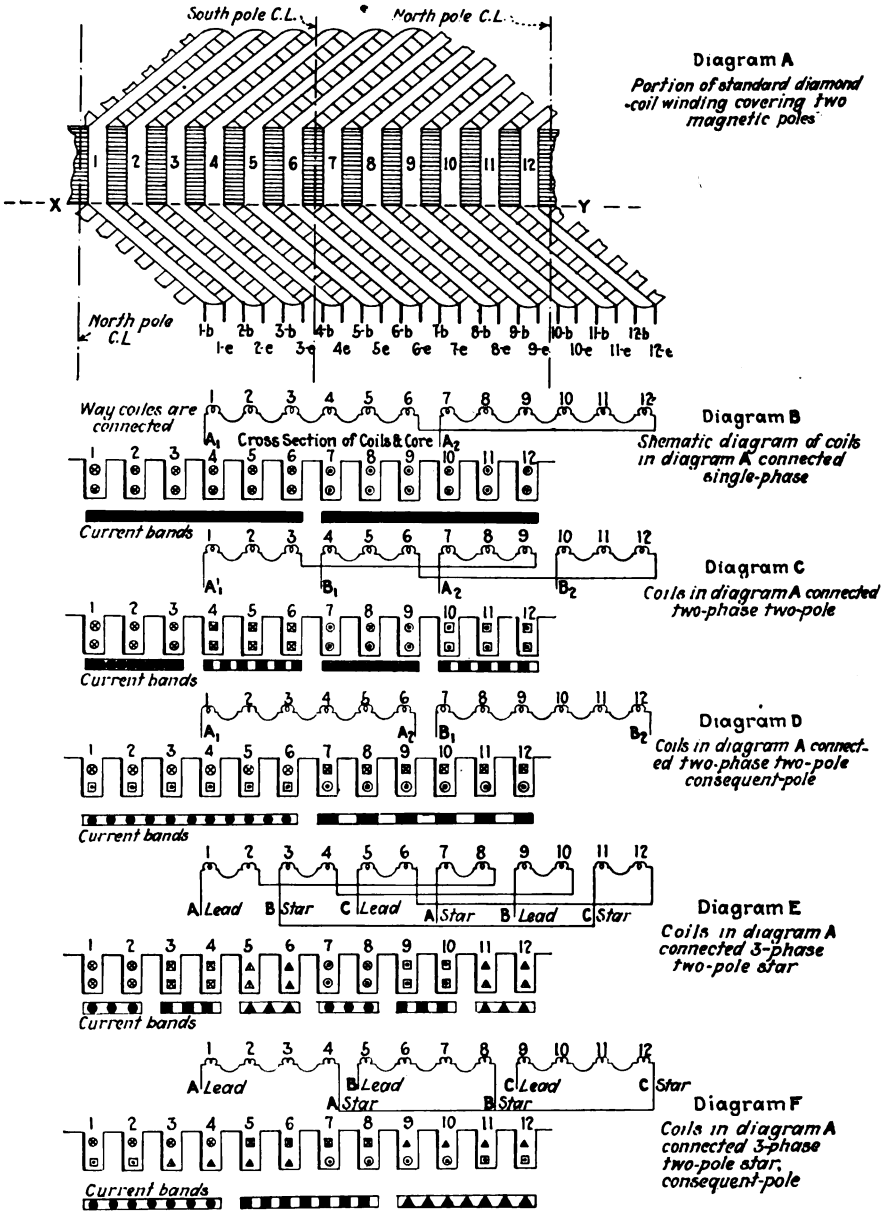


Fig. 3—Portions of typical induction motor windings and current conditions when variously connected.
In these diagrams marked A to F are shown the current conditions which exist when an induction motor winding is variously connected for two-phase or three-phase with standard connection or consequent pole connection.

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diagram *A* are connected for a standard three-phase, two-pole, star connection as shown by the schematic diagram at the top. For convenience, in the *current band* diagram at the bottom of diagram *E* the *A* phase current is represented by circles, the *B* phase by squares, and the *C* phase by triangles. It will be seen that there are six current bands per pair of poles, and hence such a connection really has as good a distribution factor as a six-phase winding. The manner of deriving the distribution factor for this winding is explained in connection with Fig. 5 below.

Finally, diagram *F* of Fig. 3 shows the conditions where the coils of diagram *A* are connected for three-phase, two-pole-star, but with a *consequent-pole* arrangement. It will be seen that there are three current bands per pair of poles. The distribution factor for this connection can be obtained from Fig. 5, as explained below. It will be noted that this connection, which is a real three-phase connection, has a distribution factor of only 0.827, whereas the usual three-phase arrangement of diagram *E* which, in turn, is really six-phase, has a distribution factor of 0.955. This is the explanation of why six-phase rotary converters are greatly to be preferred over three-phase, although requiring the increased complication of six sets of brushes and six collector rings as against two sets of brushes and three collector rings on a straight three-phase rotary.

With this preliminary physical conception of how the distribution factor is affected by the arrangement of the coil and group connections, a ready transition can be made to the geometric method of determining the value of the distribution factor as explained below in connection with Figs. 4, 5 and 6.

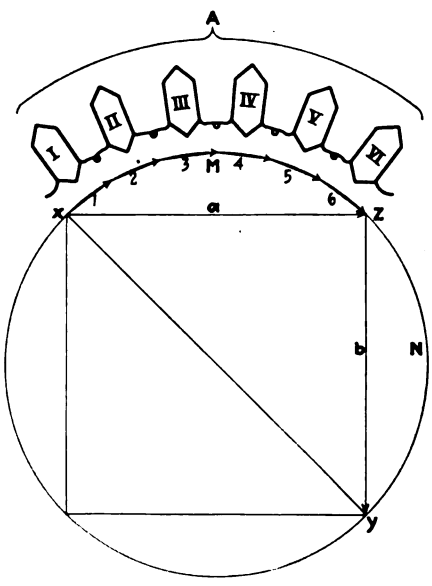


Fig. 4—Volts generated in each coil and in a pole-phase-group of six coils in a two-phase winding.

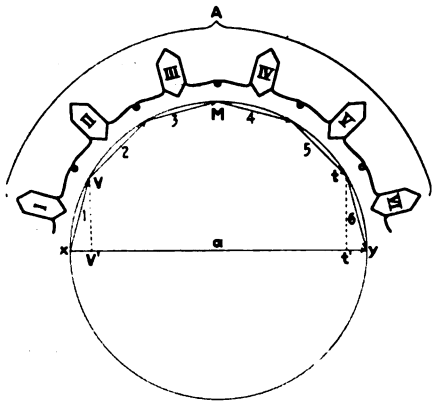


Fig. 6—Volts generated in each coil and in a pole-phase-group of six coils in a single-phase winding.

In calculating the windings for an induction motor, the number of turns required in the coils is found from this expression:

**Conductors per phase* = *(45,000,000 × volts per phase) ÷ (Cycles × magnetic flux per pole × K_1 × K_2)*. In this formula:

Conductors per phase = (Number of wires per slot which are in series × number of slots) ÷ number of phases.

Cycles = the frequency of the supply circuit as expressed in cycles per second, that is, 60 or 25, or whatever the circuit may be.

Volts per phase = line volts in the case of a two-phase winding or a delta-connected three-phase winding and line volts divided by 1.73 in the case of a star-connected three-phase winding.

Magnetic flux per pole = number of magnetic lines of force set up in each pole by the magnetizing current.

K_2 is the so-called *chord factor* depending upon the pitch or throw of the coil. *Full pitch* would mean a throw from the center of one north pole to the center of an adjacent south pole and would be called 180 electrical degrees. A *chorded winding* or *fractional pitch* winding would have a span or throw of each individual coil something less than 180 electrical degrees, and the corresponding *chord factor* or K_2 would be the *sine of one-half of this span angle*. In the case of full pitch or 180 deg., the *sine of one half of 180 deg.* or *sine of 90 deg.* = 1, and hence the turns of a winding are most effective in inducing or generating voltage when the throw of the coil is full pitch. In actual practice this is usually not done because chording one or two slots does not seriously affect the voltage generated and results in some saving of wire due to the physically shortened length of the average turn of wire in the coil.

K_1 is a different kind of factor and depends upon the phase of the winding: that is, whether it is a two-phase or three-phase or single-phase winding. It is usually called the *distribution factor*. For most of the present day distributed windings used in induction motors it can be placed equal to 0.905 for two-phase windings and 0.955 for three-phase windings and practical calculations based on these values will be accurate within close limits. In the case of single-phase windings, as explained below the *distribution factor* becomes more involved and must be worked out for each individual case.

In Fig. 1, is suggested a cross section of one pole and a part of the field yoke of a direct-current machine. In Fig. 2 is indicated a part of one end of the stator winding of an induction motor without any cross connections or leads. Consider first Fig. 1. It is readily seen that each turn of wire in the field coil surrounds all the magnetic lines of force which thread through the coil and make up one magnetic pole of the field circuit. On the other hand, in Fig. 2, it is seen that not only does

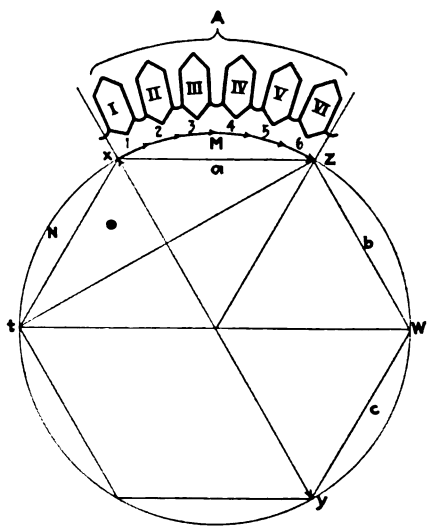


Fig. 5—Volts generated in each coil and in a pole-phase-group of six coils in a three-phase winding.

*See page 190 of the writer's book "Connecting Induction Motors," published by McGraw-Hill Book Company.

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each coil not surround all the magnetic field flux of one pole, but that there is, in addition, the complication that the magnetic field which acts as if it were set up by direct current, relies on the combination of two or three phases of alternating currents in the windings to produce this effect of a rotating direct current for magnetization.

It is the difference in the action of two-phase windings from three-phase windings that gives rise to the difference between the values of 0.905 and 0.955 cited above, and the physical reason for this difference can best be seen from geometric figures.

In Figure 4 is represented a half square erected in a semi-circle, the diameter of the circle becoming one diagonal of this inscribed square. This figure represents diagrammatically the voltages set up or induced in each individual coil in a two-phase winding, which would be the small chords subtending the small arcs *1, 2, 3, 4, 5, 6.* The coils themselves are physically pictured as *I, II, III, IV, V, VI;* also the voltage in one pole-phase-group is represented by the sides of the square *a* or *b*, where *a* would be the *A* phase and *b* the *B* phase. It also represents in the diameter of the circle *XY* the voltage induced by one rotating magnetic or *direct current* pole, which is the result of the combined action or interaction of the two-phase windings *a* and *b*.

The physical interpretation of the diagram in Fig. 4 is that if the small coils *1, 2, 3,* and so on, represent six individual coils in series forming one pole-phase-group of a two-phase winding, each coil will generate or have induced in it a voltage represented by the short chord or straight line subtending the arc representing this coil. The six coils in series would generate a total voltage equal to the sum of the six chords or practically equal to the quadrant of the circle from *X* to *Z*. This quadrant represents in its length the voltage that would be generated or induced in the pole-phase-group if all six of the coils were bunched into one coil as in the case of the direct-current machine shown in Fig. 1. However, these six coils are not bunched but are spread over an arc in the bore of the motor representing one *pole pitch*. For this reason there is a phase difference in time represented by the small angle between the chords *1* and *2*, which means that because the main magnetic field in the motor is rotating, it does not generate voltage in coil *1*, for example, at exactly the same instant that it does in coil *2*, but a fraction of a second sooner or later. Since this is true, we cannot add together end to end in one straight line the six small voltages generated by the six coils, but must add them geometrically as shown in Fig. 4, so that instead of having a voltage across the six in series, or the pole-phase-group, practically equivalent to the arc *XMZ*, the combined voltage is really the chord of this arc or the straight line *XZ*. Theoretically, the number of coils in the pole-phase-group would have to be infinite before the arithmetical sum of their voltages would be equal to the quadrant of the circle, but practically in most commercial motors this assumption can be made without serious error.

Now since the arc *XMZ* represents in its length what the combined voltage of the six coils would be if bunched or concentrated into one coil, and since the chord or straight line *XZ* represents by its length what the real voltage across the six is (since they are not quite in phase), the actual effective number of turns or what is called the *distribution factor* can be represented by the expression:

Distribution Factor = (The length of the chord XZ) ÷ [The length of small chords (1+2+3+4+5+6)].

And, since in practically all commercial windings there is a considerable number of coils in each pole-phase-group, the sum of the chords *(1+2+3+4+5+6)* can be set equal to the arc *XMZ*, as stated above, and the expression for distribution factor becomes:

Distribution Factor = (The length of the chord XZ) ÷ (The length of the arc XMZ).

Since these quantities make up the quadrant of a circle, the chord *XZ* = the radius of the circle ÷ 0.707 and the arc *XMZ* = 3.14 × the radius of the circle ÷ 2.

The expression above then becomes:

Distribution Factor = (Radius × 2) ÷ (0.707 × 3.14 × Radius) or 2 ÷ (0.707 × 3.14) = .90.

When this value is worked out for a number of practical cases involving different numbers of coils per pole-phase-group, it is found that the value 0.905 given in the general paragraph above is a satisfactory one to be used in the calculations for ordinary commercial machines.

Fig. 4 can be used, also, to derive the distribution factor for a consequent-pole winding such as that illustrated in diagram *D* of Fig 3. In this case the diameter *XY* represents the voltage induced in the winding for one pair of poles, that is to say the winding A_1-A_2 for example. This voltage may be considered as made up of the two voltages or chords *XZ* and *ZY*. In return, the voltage *XZ* may be considered the voltage set up by the physical winding making a north pole, and the voltage or chord *ZY*, representing the *consequent* pole or resulting south pole which has no winding but which is obliged to be present in order for the magnetic flux sent out by the winding to get back into the core. In other words, the direction of the current in the windings is such as to cause only one polarity, but since one polarity cannot exist without the other, the other polarity comes *in consequence* and hence is called a *consequent* pole. Referring again to Fig. 4, if the sum of all the voltages in all the individual coils is equivalent to the arc *XMZNY* and the resulting voltage at the terminals A_1-A_2 of the winding is represented by the diameter *XY*, the distribution factor is the expression:

XY ÷ (arc XMZNY) = (2 × radius) ÷ (3.1416 × radius) = 2 ÷ 3.1416 = 0.636.

This is the same as the single-phase distribution factor in Fig. 6. Another conception of this factor of 0.636 would be to say that it is the product of 0.905 and 0.707, the first being the relation of the chord *XZ* to the arc *XMZ*, and the second being the relation of the diameter *XY* to the sum of the chord *XZ*, plus the chord *ZY*. In other words, the factor 0.905 is because the winding is two-phase, and the factor 0.707 is because it is connected for consequent poles, and the product of 0.905 × 0.707 = 0.636, which makes it no better than the single-phase winding shown in Fig. 6.

Considering Fig. 5, there is illustrated a similar condition for a three-phase motor. In this case the construction is that of a hexagon inscribed in a circle. Again, the coils are physically pictured as *I, II, III, IV, V, VI* and the voltages induced in each of these coils, or the magneto-motive force set up by each, as the small chords *1, 2, 3, 4, 5, 6.* If these coils were all concentrated into one large coil, their effect would

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equal the sum of the small arcs *1, 2, 3, 4, 5, 6.* Since this is not the case and they are distributed as shown, the effect of the pole-phase-group is the chord *XZ* or *a.* Then, similarly to the two-phase case, the expression for the distribution becomes: (The length of the chord *XZ*) ÷ (The length of the arc *XMZ*). Since the chord *a* in this case is one side of an inscribed hexagon, and since the side of a hexagon is equal to the radius of the circle in which it is inscribed, this expression becomes: (Radius of a circle) ÷ (One sixth of the circumference) = (6 radius) ÷ (2 × 3.14 × radius) = 3 ÷ 3.14 = 0.955 which it is proper to use in all practical calculations for ordinary commercial machines.

From Fig. 5 may also be derived the distribution factor for a three-phase, consequent-pole winding such as that illustrated in diagram *F* of Fig. 3. In this case the chord *tz* represents the voltage induced at the terminals of one phase of the winding, as for example between the *A* lead and the *A* star. As in the case of the similar two-phase, consequent-pole winding described under Fig. 4 and diagram *D* of Fig. 3 this voltage *tz* is made up of the pieces *tx* and *xz* combined. Of these two pieces we may consider *xz* as actually caused by the ampere turns in the winding and *tx* as resulting from the consequent pole similar to the two-phase case above. Hence the distribution factor for this winding is the length of the chord *tz* divided by the length of the arc *tnxmz* or approximately 0.827. This factor can be considered as made up of 0.955 × 0.866. The first of these is due to its being a three-phase winding, as already explained above, and is the relation of the chord *xz* to the arc *tmz* and the second factor or 0.866 being due to the consequent-pole connection. This factor 0.866 is the relation of the chord *tz* to the sum of the chords *tx* + *xz.*

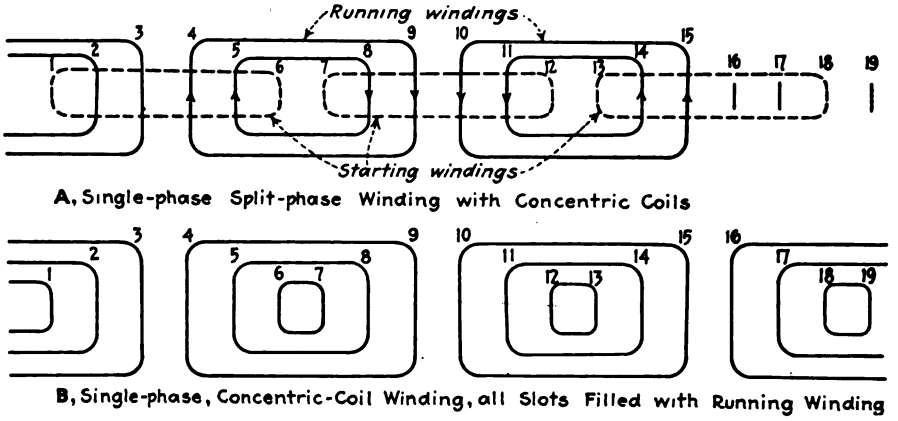


Fig. 7 — Single-phase, split-phase winding with concentric coils.
Fig. 8 — Single-phase concentric coil winding having all slots filled with the running winding.

The case of a single-phase winding, if completely distributed as shown for a two- or three-phase winding, is shown in Fig. 6. Here the illustration shows neither a square, nor a hexagon, nor a triangle inscribed in a circle, but simply the diameter of the circle itself, *xy*, is used to represent the electrical or magnetic effect of the pole-phase-group made up of the coils *I, II, III, IV, V, VI.* As in the previous cases, if the six coils were concentrated into one field coil, their total effect would be measured by the sum of the chords *1+2+3+4+5+6.* Since they are distributed and hence each one has a little different phase from the others, the combined effect of the pole-phase-group is *xy* and the expression for the distribution factor becomes:

(Diameter of a circle) ÷ (One-half the circumference) = *D* ÷ (3.14 × radius) = 2 ÷ 3.14 = 0.636.

This factor shows that there is a very inefficient use of copper because it means that something less than two-thirds of the actual number of turns in the winding is actually effective in producing the magnetic field or in inducing voltage from that field. From the figure it will be seen that the two end voltages of the group No. *I* and No. *VI* are so far out of phase as to be of little value, and that if they were left out of the winding *(Continued on page 355)*

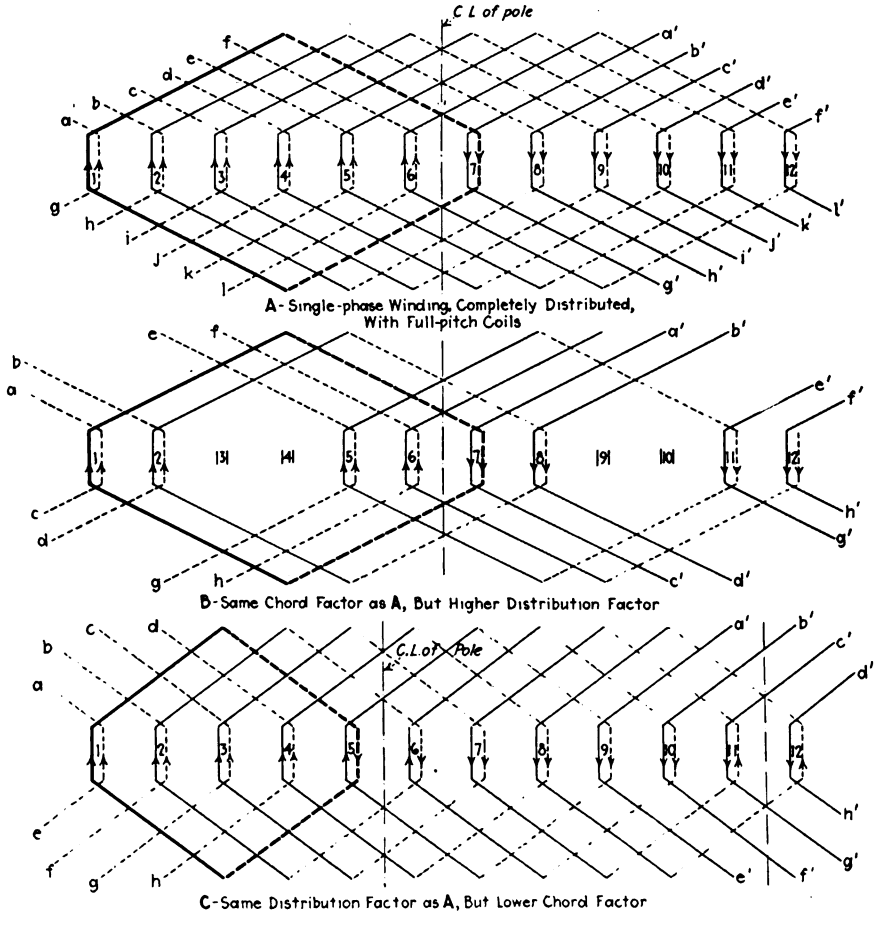
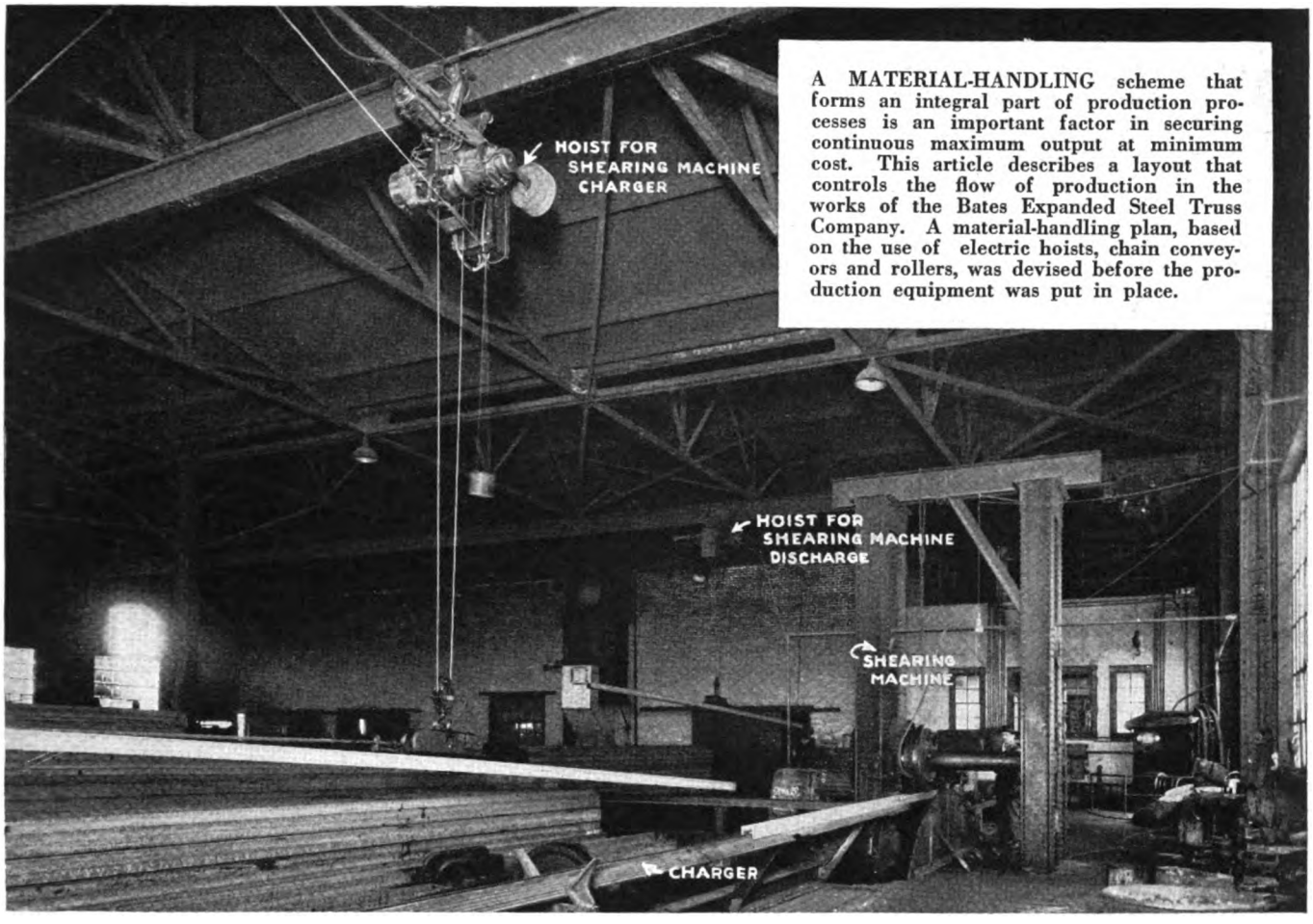


Fig. 9—Single-phase winding for two poles in twelve slots using a completely distributed winding with full-pitch coils.
Fig. 10—Single-phase winding for two poles in twelve slots with one-third of the coils omitted to improve the distribution factor of the winding.
Fig. 11—Single-phase winding for two poles in twelve slots similar to Fig. 9 except having short pitch or chorded coils.

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A MATERIAL-HANDLING scheme that forms an integral part of production processes is an important factor in securing continuous maximum output at minimum cost. This article describes a layout that controls the flow of production in the works of the Bates Expanded Steel Truss Company. A material-handling plan, based on the use of electric hoists, chain conveyors and rollers, was devised before the production equipment was put in place.

A floor-operated electric hoist is shown here placing a beam on the charging table of the shearing machine.

Here is an Instance Where

Material Moves With Production

And Handling Devices Tie Manufacturing Steps Into a Unit with Plant Expansion Effected by Adding Complete Units

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

IN MANY instances laying out a factory means placing the equipment and arranging the flow of raw materials and parts in process to conform with an existing building or group of buildings. An interesting example of a case where this process was reversed and the buildings were erected around the machines, is found at the works of the Bates Expanded Steel Truss Company, East Chicago, Ind. Here the various production processes are built around a material-handling scheme and the whole so closely interwoven that the entire plant functions as a complete unit to which no machine equipment can be added or taken away, all operations are on a time basis and the operators work with practically no supervision.

The principal product of this company is expanded steel poles for transmission line construction and the raw material is a special form of H-beam rolled for this purpose. These beams, which weigh between 250 and 1,000 lb. each and are from 20 to 35 ft. long, depending on the length of pole desired, are received on gondola cars on a siding at the rear of the plant. As will be seen from one of the accompanying illustrations, they are carried into the building and piled according to size and length by a 1-ton cage-operated, monorail electric hoist which travels on a beam running the full length of the building. The use of a lifting magnet for handling these beams was not found satisfactory inasmuch as it is impossible to pick out one beam from a pile with a magnet; therefore, a special grip was devised. This consists of an iron frame approximately 3 ft. long which is suspended from the hook on the hoist and is sufficiently narrow in the lower portion to slip between the flanges of the beam and rest on the web when the beam is lying on its side with the web horizontal. Close to the bottom and at each end of this grip there is a set of sharp steel points

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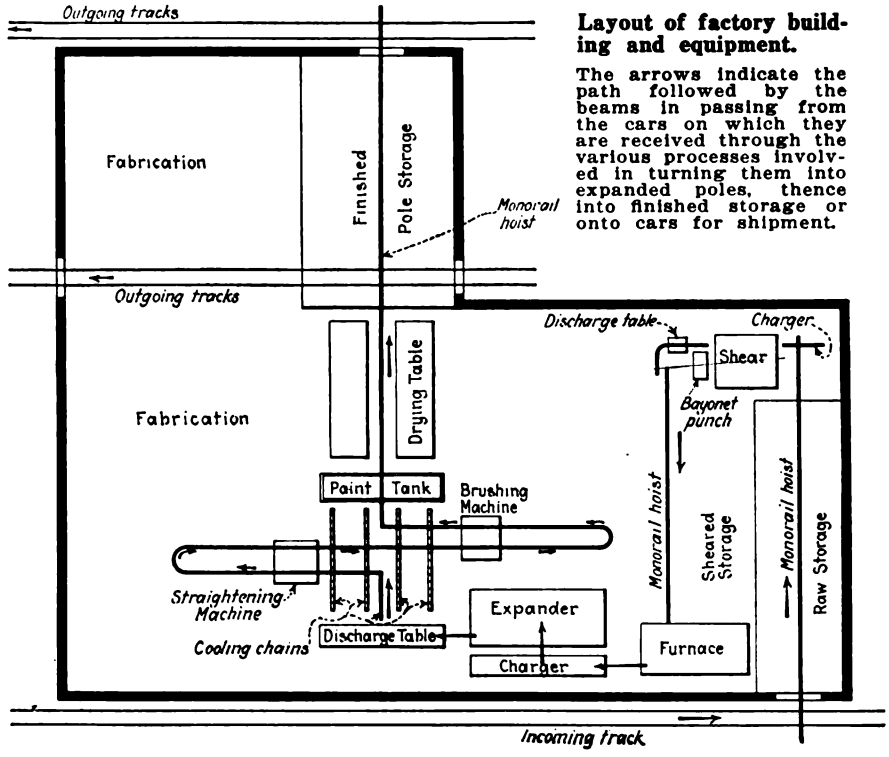
which move in and out and are controlled by the operator through a cam action. When the points are pushed out they are forced against the inner sides of the flanges of the beam so firmly that it can safely be lifted. In the case of floor-operated hoists the cam action of the grip is operated by a rod about 18 ft. long extending from the grip to the aisle. Gondola cars containing the beams are "spotted" so that the grip falls in approximately the center of the beam and the operator of the hoist can thus handle the beams from the cars to indoor storage without assistance.

From storage the beams are then moved as required to the shearing machine. In this case they are handled by a 1-ton Shepard floor-operated hoist equipped with the grip described above. The operator walks along an aisle formed by the wall of the building and the piles of beams and controls the hoist by remote control push buttons mounted in a small, especially designed case suspended from the hoist.

The shearing machine consists essentially of two revolving disks. The upper disk has continuous cutters.

The lower disk is 12 ft. in diameter, and has intermittent cutters and open portions called intacts so placed that when the beam is passed through the disks slits are cut in the web to allow the beam to be expanded, as will be explained later. The two disks are in effect a revolving punch and die.

As the beams are taken from storage they are placed on a narrow, charging table through which passes an endless chain fitted with dogs.



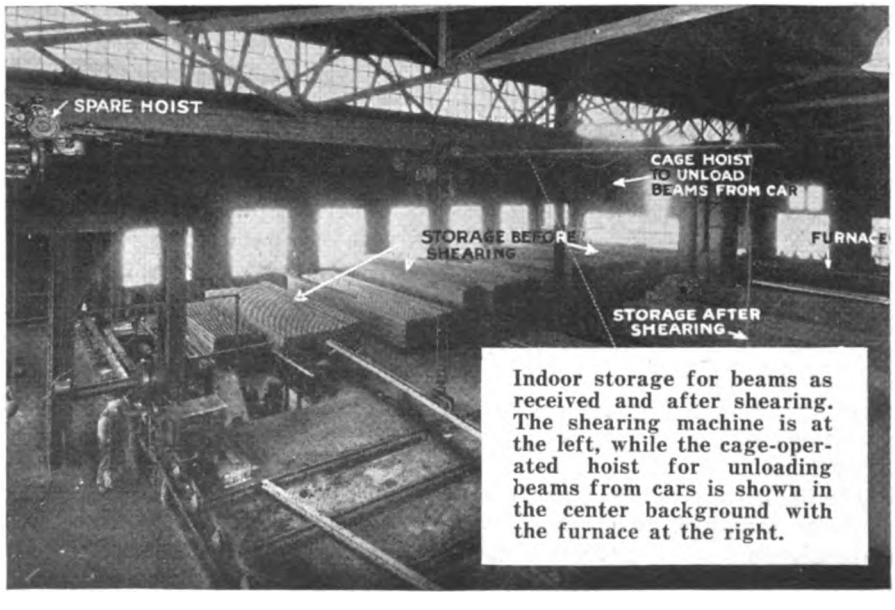
Layout of factory building and equipment.

The arrows indicate the path followed by the beams in passing from the cars on which they are received through the various processes involved in turning them into expanded poles, thence into finished storage or onto cars for shipment.

This is a part of the shearing machine and charges the beam through the shear. The disks revolve continuously but the driving mechanism of the chain is automatically controlled so that the beams are pushed between them at the right time to cut the slits in the proper position. This action is entirely automatic and beyond the control of the operator; he merely steps on a foot lever after the beam has been placed on the charger. Another feature of the automatic mechanical control of the shearing machine is that a beam cannot be charged into it until the last preceding beam has been removed from the discharge table. This is a fool-proof device to prevent the beam which is being sheared from pushing the previously sheared beam through the side of the building. After passing through the shear the beams pass out on a set of rollers which form a narrow discharge table. While they are on this table two holes for attaching a bayonet are punched in what will be called the upper end of the pole. From the discharge table the beams are picked up and moved either to sheared storage or direct to the furnace, where they are heated prior to being expanded. A 2-ton Shepard floor-operated electric hoist and grip is used for this handling.

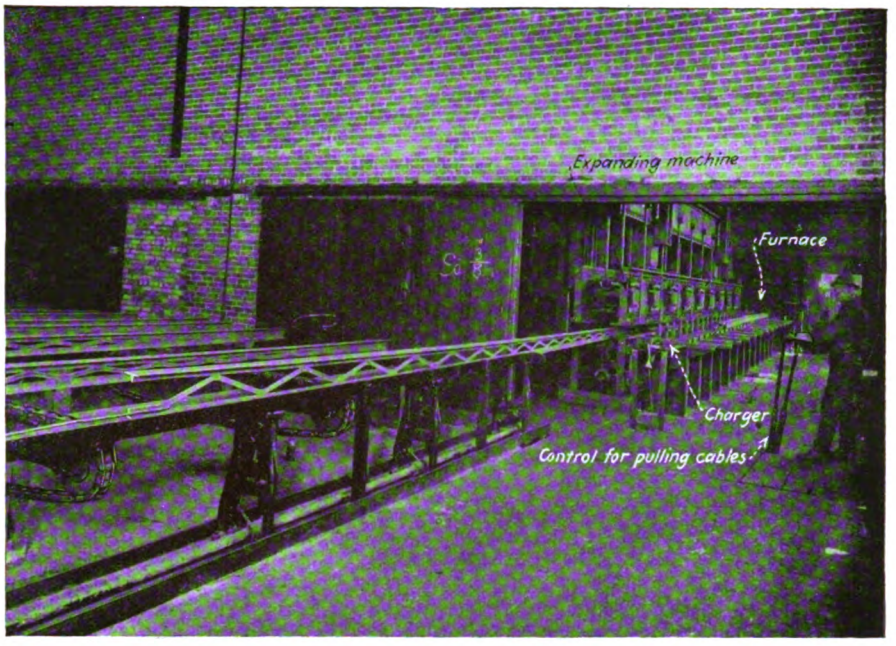
The heating furnace is 36 ft. long and may be fired either by a battery of eight oil burners or by sixteen artificial gas burners. The beams are deposited by the hoist on a table which runs the long way of the furnace and are pushed into it broadside by an hydraulically-driven charging device. They are removed one at a time from one end of the furnace. When one beam is taken out the operator pulls a lever which controls the furnace charger, and the beams on the table, and those which are already in the furnace are automatically pushed forward just far enough to bring the next beam in front of the opening in the furnace end.

The beams are pulled out of the furnace one at a time and onto the table of the expanding machine charger by a steel cable which passes around one of two winding drums



Indoor storage for beams as received and after shearing. The shearing machine is at the left, while the cage-operated hoist for unloading beams from cars is shown in the center background with the furnace at the right.

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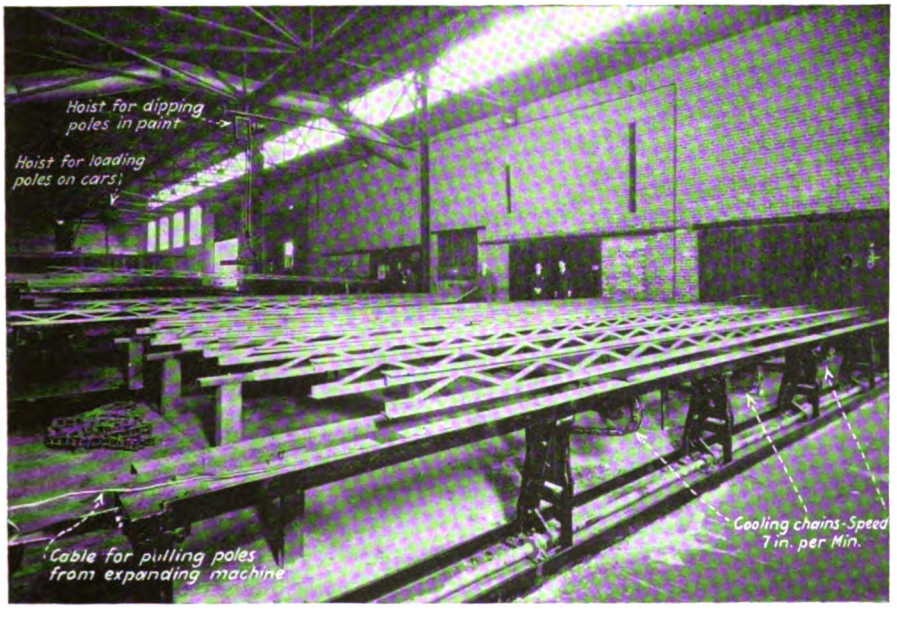
The expanding machine transforms slitted beams into expanded poles.
At the right, a red-hot beam is being pulled onto the expanding machine charger from the furnace, while an expanded beam or pole is being pulled from the expanding machine to the narrow discharge table from which it will be discharged onto the cooling chains at the right of the illustration. The expanding operation requires about two minutes and sets the pace for the other operations. The beams are pulled from the furnace and from the expanding machine by small steel cables which pass over two winding drums driven by a 3-hp. motor through two friction clutches. The operator at the left controls the action of the drums by the two levers shown.

which are driven by a 3-hp. motor and controlled by two Dodge friction clutches.

As the beams, which are heated to a temperature ranging from 1200 deg. F. to 1400 deg. F., are pulled out of the furnace onto the table of the charging machine, they rest on the flanges. The charger turns the beams through a 90-deg. angle so that they rest on one side and then pushes them between the jaws of the expanding machine. This expander consists in effect of an upper and lower set of parallel jaws approximately 36 ft. long. In the expanding operation the lower flange of the beam is gripped and held down by the lower set of jaws. The upper flange is likewise gripped by the upper set of jaws, which are capable of vertical movement and are raised by hydraulic power. In the manufacture of parallel-expanded beams both ends of the upper jaws are raised simultaneously and through the same distance. In making ordinary expanded poles, however, only one end of the upper set of jaws is raised, thus producing a tapering pole, the base of which is approximately 2½ times the width of the top. During the expanding process the web of the beam separates along the slits which were cut in the shearing machine, so that the final result is a pole consisting of what were the two flanges of the beam joined by the lattice-like truss portions of the web, which remain after the expanding process. The charger and expanding machine are controlled by one operator through a set of levers. The operation of these machines is practically automatic.

When the jaws of the expanding machine release, the expanded beams are drawn endwise onto a discharge table by a cable which passes over the second of the two winding drums mentioned previously. They are then discharged onto a set of four endless chains driven by a 3-hp. motor through spur and worm gears for speed reduction. These chains travel at the rate of 7 in. per min. and the poles are thus given time to cool to about 300 deg. F. before the next operation, which is straightening, or removing any crookedness which may have been caused by the preceding operations.

The poles, after traveling on one flange for about 25 ft. on the cooling chains, are rolled by hand over onto the other flange and onto 8-in. ball-bearing rollers, approximately 4 ft. long and placed parallel to the chains. They are then passed endwise to the left through the straightening machine. This machine is essentially a double "bulldozer," one on each side, working in opposite directions. When the bottom flange of a pole is straightened the pole is *(Continued on page 372)*



The expanded poles are allowed to cool on slow-moving cooling chains on their way to the paint tanks.
These endless chains, of which there are four, carry the poles from the expanding to the straightening operation at a speed of 7 inches per minute. The operator in the center of the illustration has just tipped a pole from the chains onto ball-bearing rolls which are placed parallel and close to the cooling chains, preparatory to sending it to the left through the straightening machine, not shown here. From the straightening machine the poles are pushed on the rollers back across the cooling chains and through the door directly behind the operator of the floor-operated hoist to the brushing machine. From the brushing machine the poles are again slid onto the cooling chains, after which they are picked up by the 1-ton Shepard hoist shown at the left, dipped in paint, and placed on a drying table. Here they are picked up by one of the two 3-ton cage-operated electric hoists shown on the left and placed in indoor storage or loaded on cars for shipment.

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SUCCESSFUL OPERATION of transformers is dependent upon proper installation and operation as well as upon proper design and manufacture. While a transformer requires less care than almost any other type of electrical apparatus, neglect of certain fundamental requirements may lead to serious trouble, if not to loss of the transformer. These instructions have been prepared to the end that avoidable troubles may be prevented by intelligent handling and care.

This is a 22,000-volt steel tower substation at Leggitts Creek Anthracite Company, Scranton, Pa. Three transformers have a rating of 250 kva., 22,000 volts to 440 volts, and three are rated at 333 kva., 22,000 volts to 220 volts. At present electrical equipment is installed for a third bank of three 500-kva., 22,000- to 2,200-volt transformers. The high-tension outdoor metering equipment is mounted on a platform in the steel tower.

Recommendations of Electric Power Club for

Care and Operation of Power Transformers

From the Standpoint of Those In Charge of Their Installation and Maintenance

GENERAL instructions for the care and operation of power transformers have just been prepared by the transformer section of the Electric Power Club and published for the use of operating and maintenance engineers. These instructions apply primarily to power transformers (sizes above 200 kva.) but they also apply to distribution transformers (sizes 200 kva. and smaller) in the higher voltage classes.

It is recognized that transformers are given less care than apparatus having moving parts; nevertheless, the neglect of certain fundamental requirements may lead to serious troubles if not to the loss of the transformers. Such fundamental maintenance and operating instructions have been covered in the recommended procedure prepared by the Electric Power Club. These instructions are given in full in what follows. They can be secured in pamphlet form from the Executive Secretary of the Electric Power Club, Keith Building, Cleveland, Ohio, or from the following member companies of the transformer section: Allis-Chalmers Mfg. Company, Milwaukee, Wis.; American Transformer Company, Newark, N. J.; Duncan Electric Mfg. Company, Lafayette, Ind.; Enterprise Electric Company, Warren, Ohio; General Electric Company, Schenectady, N. Y.; Kuhlman Electric Company, Bay City, Mich.; Moloney Electric Company, St. Louis, Mo.; Packard Electric Company, Warren, Ohio; Pittsburgh Transformer Company, Pittsburgh, Pa.; Wagner Electric Corporation, St. Louis, Mo.; Westinghouse Electric & Mfg. Company, E. Pittsburgh, Pa.

This is the first set of instructions, aside from the Industrial Control Handbook, that has been compiled

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by the Electric Power Club on the care and operation of apparatus. It is planned to issue similar instructions on other apparatus within the scope of its activities. Another practical pamphlet prepared by the transformer section and issued in pamphlet form, covers transformer standards. A revised edition of this will be available in the near future.

LOCATION

Accessibility, ventilation and ease of inspection should be given careful consideration in locating transformers.

Water-Cooled Transformers depend almost entirely upon the flow of water through the cooling coils for carrying away heat so that the temperature of the surrounding air has little effect upon that of the transformers. For this reason air circulation is of minor importance and water-cooled transformers may be located in any convenient place without regard to ventilation.

Self-Cooled Transformers depend entirely upon the surrounding air for carrying away their heat. For this reason care must be taken to provide adequate ventilation. For indoor installation the room in which the transformers are placed must be well ventilated so that heated air can escape readily and be replaced by cool air from outside. They must be so located that water cannot fall on the tanks or rain blow upon them, if of the indoor type.

Self-Cooled Transformers should always be separated from one another and from adjacent walls, partitions, etc., in order to permit free circulation about the tanks. This separation should not be less than 24 inches to 36 inches, depending on size.

When the transformer can be set up immediately in its permanent location and filled with oil, it is advisable to do so, even though it will not be put into service for some time. If this is not convenient it should be stored in a dry place, having no rapid or radical temperature changes, and if possible, immersed in dry transformer oil. The transformer should not be stored or operated in the presence of corrosive gases such as chlorine, etc. If stored *OUTDOORS*, it should be thoroughly covered to keep out rain.

When lifting a transformer, the lifting cables must be held apart by a spreader to avoid bending the lifting studs or other parts of the structure.

Where a transformer cannot be handled by a crane, it may be skidded or moved on rollers, but care must be taken not to damage the base, or tip it over. A transformer should never be lifted or moved by placing jacks or tackle under the drain valve, cooling coil outlets, radiator connections or other attachments. When rollers are used under large transformers, skids must be used to distribute the stress over the base.

INSTALLATION

When working about a transformer particular care must be taken in handling all tools and other loose articles, since anything metallic dropped among the windings and allowed to remain there may cause a breakdown.

When shipped by the manufacturer, transformers are in first class operating condition. That is, they have been thoroughly tested for defects and are perfectly dry.

When received, examination should be made before removing from cars and if any injury is evident or any indication of rough handling is visible, railroad claim should be filed at once and manufacturer notified.

Moisture may condense on any metal if the metal is colder than air, and if present, it lowers the insulation properties and may cause failure of transformer. Therefore, if transformers or oil drums are brought into a room warmer than they are, they should be allowed to stand before opening until there is no condensation on the outside and they are thoroughly dry.

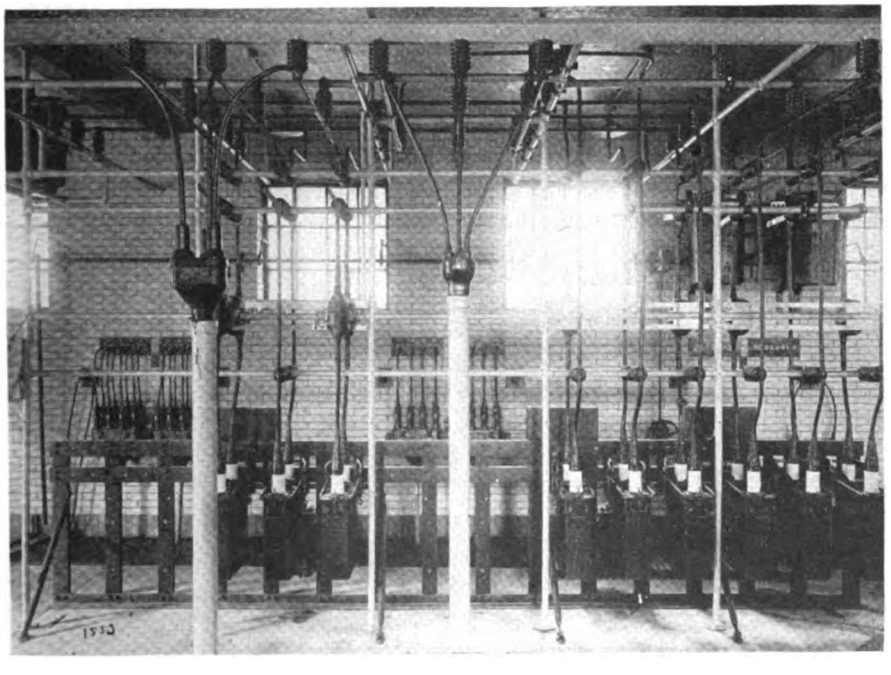
Before being set up, a transformer should be inspected for breakage, injury or misplacement of parts during shipment, and thoroughly examined for moisture, and all accessible nuts, bolts and studs should be tightened.

If transformers are water cooled, test the cooling coils for leaks, at a pressure of 80 to 100 lb. per sq. in. Water, oil or preferably air, may be used in the coil for obtaining the pressure. The coil must be outside of the tank, that is away from the coil insulation if water is used for the pressure test. When pressure is obtained, disconnect the supply and after one hour determine whether any fall in pressure is due to a leak in the coil, or is in the fittings at the ends of the coils.

Transformers Shipped Filled With Oil.—Each transformer shipped filled with oil should be inspected to see whether there is any condition indicating the entrance of moisture during shipment.

If the transformer is received in damaged condition, so that water or other foreign material has had a chance to enter the tank, the transformer should be emptied of oil and treated as though not shipped in oil, and in no case may drying be omitted.

In all cases samples of oil should be taken from the bottom and tested. The dielectric strength of the oil when shipped is at least 22 kv. be-



This photograph shows a section of a 6,600-volt indoor substation of the Eastman Kodak Company, Rochester, N. Y.

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tween 1-in. disks spaced 0.1 in. apart. A new transformer should not be put into service with oil which tests below this value.

Transformers Shipped Assembled Without Oil. — Each transformer shipped assembled but not filled with oil should be carefully inspected for damage in shipment. A thorough inspection can only be made by removing core and coils from the tank. All dirt should be wiped off and parts examined for breakage or other injuries. All conductors and terminals should be examined to check their proper condition and position. Tighten coil and core clamps if necessary.

The tank should be inspected and, if necessary, cleaned.

When a transformer is shipped assembled but not filled with oil, moisture may be absorbed during transportation. For this reason it is good practice to dry out all such transformers, especially transformers above 7,500 volts before they are put into service.

Transformers Shipped Disassembled.—Only very large transformers are shipped in this way, and special instructions covering features incident to this method of shipping are supplied by the manufacturer. These instructions should be carefully followed.

Drying Core and Coils

There is a number of approved methods of drying out transformer core and coils, any one of which will be satisfactory if carefully performed. Too much stress, however, cannot be laid upon the fact that if carelessly or improperly performed, great damage may result to the transformer insulation through overheating.

The methods in use may be broadly divided into two classes: First, drying with the core and coils in the tank and filled with oil, and second, drying with the oil removed. In the latter case the core and coils may or may not be removed from the tank.

Under the first class, the moisture is driven off by sending current through the winding while immersed in oil, with the top of the tank open to the air, or some other arrangement made for adequate ventilation. This may be done by (1) the short circuit method (to be used if the transformer is new or has been out of service without oil any length of time). (2) Normal operation method (to be used if the transformer is already in service but shows moisture condensation and the transformer cannot be shut down to apply the short circuit method).

Short Circuit Method With Oil.— This method consists in heating the windings and oil up to a high temperature for a limited time under short circuit with a partial load on the windings, the high oil temperature being obtained by blanketing the tank (or reducing the flow of water for water-cooled transformers). In using this method, if the load does not exceed one-half or three-quarters full load, the winding temperature is not greatly in excess of the maximum or top oil temperature, so that high oil temperatures are safe without resulting in any deterioration of the insulation from local over-heating. With good ventilation, the moisture, as it is driven off in the form of vapor will escape to the outside atmosphere and no condensation of moisture will take place on the underside of the cover or elsewhere in the tank.

The following table shows the short circuit current in per cent of full load current which may be used, for this method of drying transformers, with the corresponding maximum allowable top oil temperature in degrees centigrade.

Short Circuit Amp. in Percent of Full Load		Maximum Top Oil Temperature
Self Cooled Transformers	Water Cooled Transformers	
50	50	85° C.
75	60	80° C.
85	75	75° C.

These temperature limits and loads must be strictly adhered to in order to obtain the desired results without danger to the transformers.

It should be noted that the higher allowable temperatures go with the smaller loads, that is, more blanketing or less water will be required for the smaller loads than for the higher in order to bring the oil temperature up to the point shown in the table.

Ventilation.—During the drying run, additional ventilation to that ordinarily provided should be maintained by slightly raising the manhole cover and protecting the opening from the weather.

When to Discontinue Drying.—Dielectric tests of oil samples from the bottom and top of the tank should be made twice daily while the transformer is hot. As soon as successive tests over a period of 24 hours (with the oil maintained at maximum temperature, *AND WITHOUT TREATING WITH THE FILTER PRESS*), show that the oil has met a test of 22 kilovolts with 1-in. discs set 0.1 in. apart, the drying run may be discontinued.

Another check on the effectiveness of the drying is to close up the ventilating holes and operate in this manner for 24 hours at the maximum oil temperature, chill the manhole cover, and then open and examine for condensation.

Normal Operation Method.—This method consists in providing ventilation in the cover, as explained above, and blowing air across the top oil, say by a desk fan, while the transformer is under normal operation.

Inspect the manhole cover frequently and raise the oil temperature by blanketing the tank or increasing the load. If condensation appears on the under side of the manhole cover, reduce the oil temperature and run until moisture disappears, then raise the temperature again.

The following table will show the highest permissible load current for maximum top oil temperatures of 70, 75 and 85 degrees:

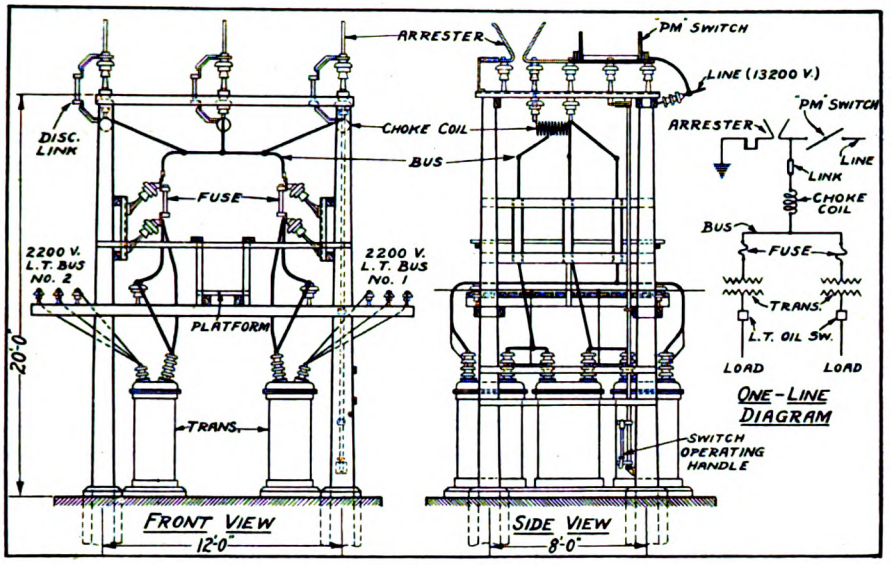
Load Amp. in Percent of Full Load		Maximum Top Oil Temperature
Self Cooled Transformers	Water Cooled Transformers	
50	50	85° C.
85	75	75° C.
100	85	70° C.

Continue for three days at maximum temperature; then if no condensation occurs, drying may be discontinued as outlined above in the paragraph "When to Discontinue Drying."

Typical of the second class, i. e., drying with the oil removed, are the three following methods: (a) by internal heat, (b) by external heat, (c) by internal and external heat.

(*a*) *By Internal Heat.*—For this method alternating current is required. The transformer should be placed in its tank without the oil and the cover left off to allow free circulation of air. The low-voltage winding should be short circuited and sufficient voltage impressed across the high-voltage winding to circulate enough current through the coils to maintain the temperature at from 75 deg. to 80 deg., centigrade. About one-fifth of normal full-rated current is gen-

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Plan of out-door substation with common high-tension switching and lightning arrester equipment for two separately fused transformer banks supplying independent loads.

erally sufficient to do this. The impressed voltage necessary to circulate this current varies within wide limits among different transformers, but will generally be approximately one-half per cent to one and one-half per cent of normal voltage, at normal frequency.

The end terminals of the winding must be used, not taps, so that current will circulate through the total winding. The amount of current may be controlled by a rheostat in series with the exciting winding.

This method of drying out is superfiicial and slow and should only be used with small transformers, and then only when local conditions prohibit the use of one of the other methods of drying out described here.

(*b*) *By External Heat.* — The transformer should be placed in a wooden box with holes in the top and near the bottom to allow air circulation. The clearance between the sides of the transformer and the box should be small so that most of the heated air will pass up through the ventilating ducts among the coils and not around the sides. The heat should be applied at the bottom of the box.

The best way to obtain the heat is from grid resistors, using either alternating or direct current. The temperature limits are the same as for method *(a)*. The transformer must be carefully protected against direct radiation from the heaters. Care must also be taken to see that there is no inflammable material near the heaters, and to this end it is advisable to completely line the wooden box with asbestos.

Instead of placing the heater inside the box containing the transformer, it may be placed outside and the heat carried into the bottom of the box through a suitable pipe. Where this plan is followed, the heat may be generated by the direct combustion of gas, coal or wood, provided that none of the products of combustion be allowed to enter the box containing the transformer. Heating by combustion is not advocated except when electric current is not available.

This method, while effective, requires a much longer time than method *(c)*.

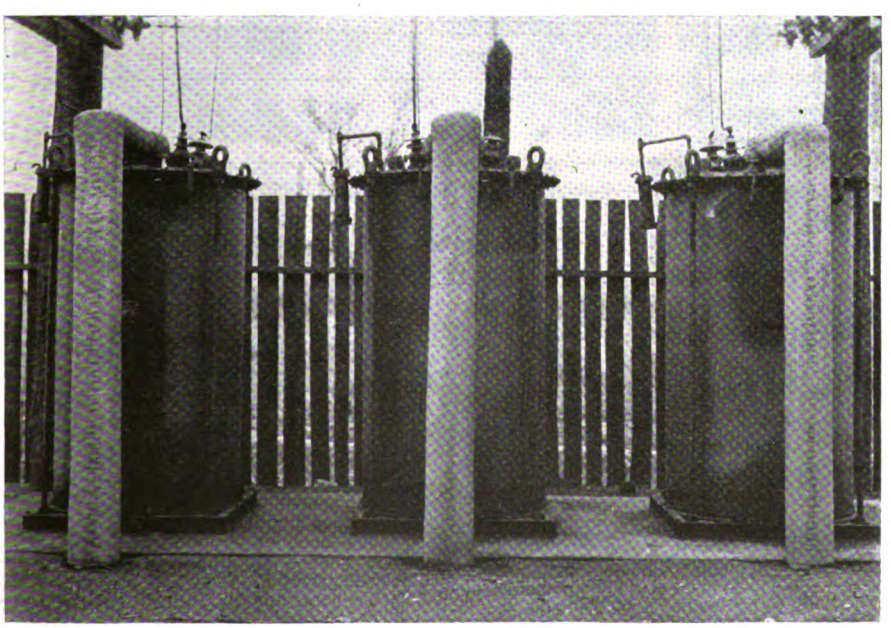
(*c*) By *Internal and External Heat.*—This is a combination of methods *(a)* and *(b)*. The transformer should be placed in a box and external heat applied as in *(b)* and current circulated through the windings as in *(a)*. The current should, of course, be considerably less than when no external heat is applied.

This method is used occasionally where direct current only is available, a certain amount of current being passed through the high-voltage winding only, as the cross-sectional area of the low-voltage conductor is generally too large for it to be heated with an economical amount of direct current. The use of direct current for drying out is not recommended except where alternating current cannot be obtained. When this method of drying is used, temperature should be measured by increase in resistance.

Method *(c)* is quicker than either *(a)* or *(b)* and has the great advantage that the insulation is heated much more uniformly.

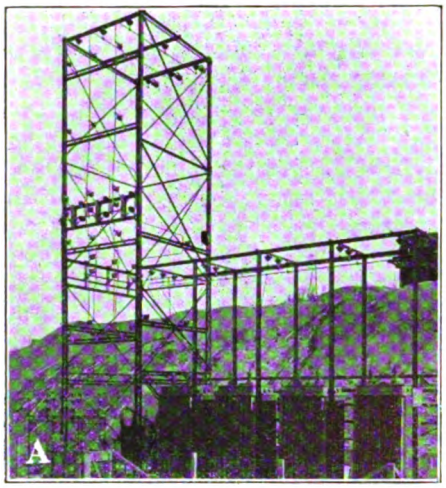
Time Required for Drying.—There is no definite length of time for drying. One to three weeks will generally be required, depending upon the condition of the transformer, the size, the voltage and the method of drying used.

Insulation Resistance.—Insulation resistance is of value in determining the course of drying only when the transformer is without oil. If the initial insulation resistance be measured at ordinary temperatures, it



Water-cooled transformers rated at 833 kva., 60 cycles, 13,000-2,200 volts, on the lines of Harrisburg Light & Power Company, Harrisburg, Pa. These transformers are airtight and moisture proof. The water pipes are covered with asbestos to prevent freezing of the water in winter weather.

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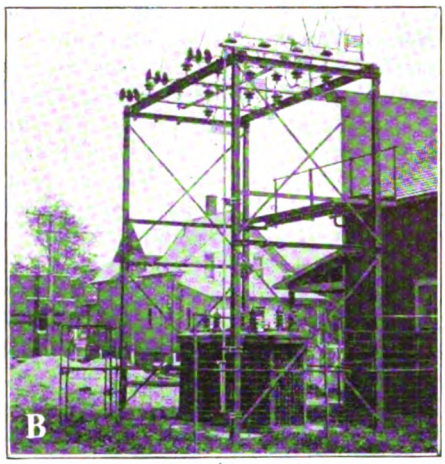


Some Conditions That Surround

Power Transformers

In outdoor industrial substations where proper installation, inspection and maintenance insure continuous service. The photographs were furnished through courtesy of Delta-Star Electric Company, Chicago, Ill.

A—Step-down steel tower substation with four 1,667-kva., 22,000- to 4,000-volt transformers with one spare on the lines of Monongahela Power Company, supplying power to the West Virginia Metal Products Company's brass mill at Fairmont, W. Va.



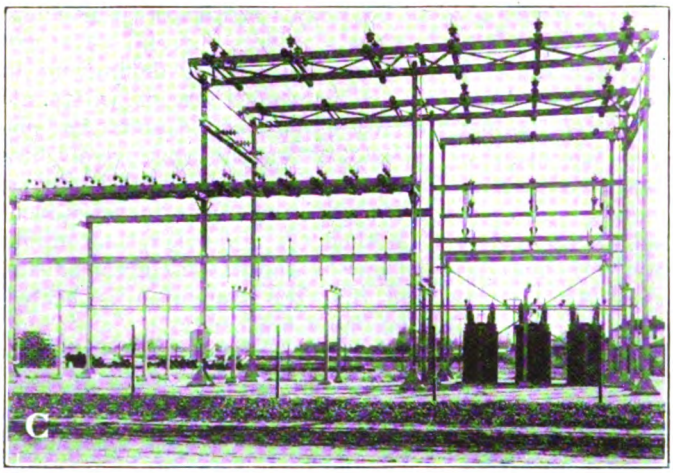
B—Steel-tower substation with a bank of three 200-kva., 22,000- to 2,200-volt transformers supplying industries in a small town.

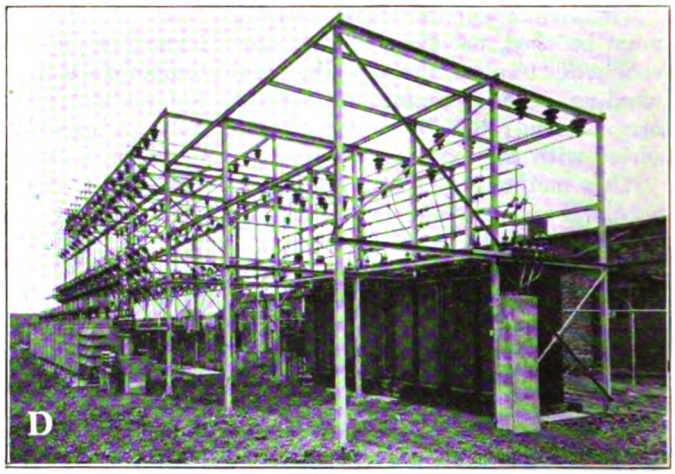
C—Combination switching tower and step-down substation with three 333-kva., 66,000- to 13,200-volt transformers, provision being made to add a future bank. This station is owned by the Arkansas Valley Railway, Light & Power Company, and is located at Fowler, Colo., supplying power to several towns and local industries.

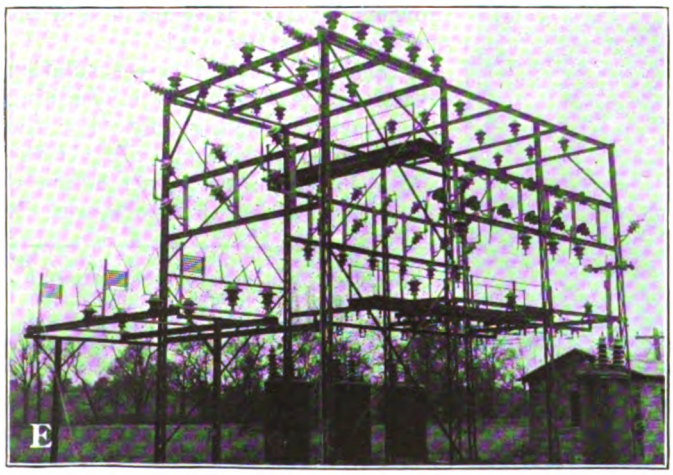
D—This photograph shows a combination switching and transformer station for 33,000-volt service, having four 33,000-volt incoming lines, three of which are direct connected to a 50,000-kva. generating station while the fourth supplies another large substation.

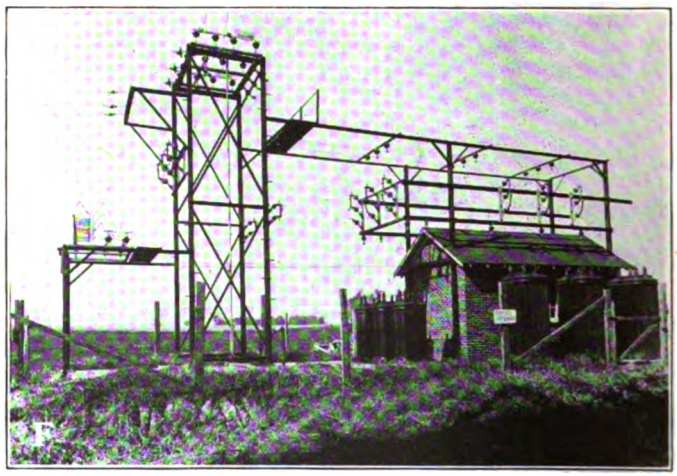
E—Steel-tower substation with four 3,300-kva., 66,000- to 4,000-2,300-volt transformers, and one spare, at a mine of the Wayne Coal Company, New Lexington, Ohio.

F—This station was designed to use six 400-kva., 16,200- to 440-volt, and three 75-kva., 13,200 to 2,300-volt power transformers, and one 10-kva., 2,300- to 110-volt lighting transformer. The high-tension metering equipment is placed below the main structure.









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may be high although the insulation is not dry, but as the transformer is heated up, it will drop rapidly.

As the drying proceeds at a constant temperature, the insulation resistance will generally increase gradually until towards the end of the drying period when the increase will become more rapid. Sometimes the resistance will rise and fall through a short range one or more times before reaching a steady high point. This is caused by moisture in the interior parts of the insulation working its way out through the outer portions which were dried at first. As the temperature varies, the insulation resistance also varies greatly, wherefore the temperature should be kept nearly constant and the resistance measurements should all be taken at as nearly the same temperature as possible. The insulation resistance in megohms varies inversely with the temperature and for a 10 deg. centigrade change of temperature, the megohms change by a ratio of 2:1. Measurements should be taken every two hours during the drying period.

Resistance Curve.—A curve of the insulation resistance measurements should be plotted with time as abscissae and resistance as ordinates. By observation, the knee of the curve (i. e., the point where the insulation resistance begins to increase more rapidly) can be determined and the run should continue until constant for 12 hours.

Precautions to Be Observed in Drying Without Oil.—As the drying temperature approaches the point where fibrous materials deteriorate, great care must be taken to see that there are no points where the temperature exceeds 85 deg. centigrade. Several thermometers should be used and they should be placed well in among the coils near the top and screened from air currents. Ventilating ducts offer particularly good places in which to place some of the thermometers. As the temperature rises rapidly at first, the thermometers must be read at intervals of about one-half hour. In order to keep the transformer at a constant temperature for insulation resistance measurements, one thermometer should be placed where it can be read without removing or changing position. The other thermometers should be shifted about until the hottest points are found, and should remain at these points throughout the drying period. Wherever possible, the temperature should be checked by the increase of resistance method.

Caution.—It is well to have a chemical fire extinguisher or a supply of sand at hand.

It is not safe to attempt the drying out of transformers without giving them constant attention.

Sampling and Testing of Oil

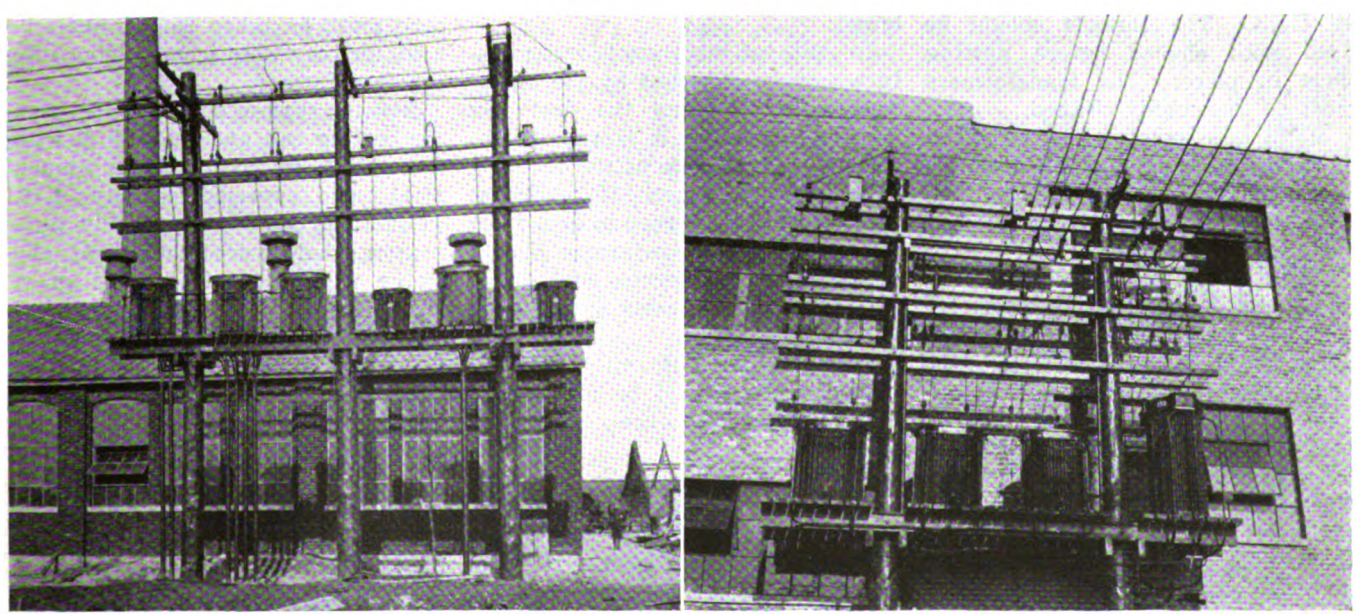
The sample container should be a large-mouth, glass bottle. All bottles should be cleaned and dried with gasoline before being used. Cork stopper should be used.

The sample for dielectric tests should be at least 16 oz., and if other tests are to be made, one quart (32 oz.).

Test samples should be taken only after the oil has settled for some time, varying from eight hours for a barrel to several days for a large transformer. Cold oil is much slower in settling and may hardly settle at all. Oil samples from the transformer should be taken from the oil sampling valve at the bottom of the tank. Oil samples from a barrel should be taken from the bottom of the drum. A brass or glass "thief" can be conveniently used for this purpose. The same method should be used for cleaning the "thief" as is used for cleaning the container.

When drawing samples of oil from the bottom of the transformer or large tank, sufficient oil must first be drawn off to make sure that the sample will be comprised of oil from the bottom of the container, and not from the oil stored in the sampling pipe. A glass receptacle is desirable so that if water is present, it may be readily observed. If water is found, an investigation of the cause should be made and a remedy applied. If water is not present in sufficient quantity to settle out, the oil may still contain considerable moisture in a suspended state. It should, therefore, be tested for dielectric strength.

Testing.—For testing oil for dielectric strength, some standard device for oil testing should be used. The standard oil testing spark gap has disk terminals one inch in diameter spaced one-tenth inch apart. The testing cup should be cleaned



At the left, are three 75-kva., three-phase power transformers and two 40-kva. transformers for welding service, at a large industrial plant. The transformers for welding service are connected for single-phase on three-phase circuit. At the right, three 75-kva. three-phase power transformers and one 150-kva. single-phase lighting transformer.

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thoroughly to remove any particles of cotton fibre, and rinsed out with a portion of the oil to be tested.

The spark gap receptacle should be nearly filled with oil and allowed to stand for a few minutes to give bubbles time to escape before making the test.

The rate of increase of voltage should be about 3 kv. per second. The average voltage of five tests is usually taken as the dielectric strength of the oil. Five breakdowns should be made on each filling, and then the receptacle emptied and refilled with fresh oil from the original sample. The test should be continued until the mean of the averages of at least three fillings are consistent.

The dielectric strength of oil when shipped is at least 22 kv. tested in the standard gap. If the dielectric strength of the oil in a transformer in service tests at less than 16,500 volts, it should be filtered. New oil of less than the standard dielectric strength should not be put in a transformer.

Drying Oil and Filling Transformer

In removing moisture from transformer oil, it is preferable to filter from one tank and discharge into another, although if necessary it may be drawn from the bottom of a tank and discharged at the top. When there is much water in the oil, it should be allowed to settle, then drawn off and moisture treated separately.

Filling Transformers.—Before the transformer is filled with oil, all accessories, such as valves, gages, thermometers, plugs, etc., must be fitted to the transformer and made oil tight. The threads should be filled with shellac before putting them in place. The transformers must be thoroughly cleaned.

Metal hose must be used instead of rubber hose, because oil dissolves the sulphur found in rubber, and may cause trouble by the sulphur attacking the copper.

After filling the transformer, the oil should be allowed to settle at least 12 hours and then samples taken from the bottom should be again tested before voltage is applied to the transformer.

It is very important that the surfaces of the oil when cold (25 deg. C.) be at the oil level indicated by the mark on the oil gage. When the transformer is not in service, the oil level must never be allowed to fall to a point where it does not show in the gage. As the oil heats up with the transformer under load, it will expand and rise to a higher level.

First Time in Service.—When the voltage is first applied to the transformer it should, if possible, be brought up slowly to its full value so that any wrong connection or other trouble may be discovered before damage results. After full voltage has been applied successfully, the transformer should preferably be operated in that way for a short period without load. It should be kept under observation during this time and also during the first few hours that it delivers load. After four or five days' service it is advisable to test the oil again for moisture.

Water Circulation.—If the transformer is water cooled, open the main water valve as soon as oil temperature reaches 45 deg. C. If there are two or more sets of cooling coils in parallel, adjust the valves of all sections for equal rates of flow. This can be estimated by feeling the weight of the discharge streams from the different sections. It can be determined best, however, by noting the difference in temperature between ingoing and outgoing water from each section. A careful measure should be taken of the total amount of water flowing through all sections and the total rate of flow adjusted to that called for.

Care

The idea that a transformer in service needs no attention may lead to serious results. Careful inspection is essential, and the directions given in this section should be followed.

In spite of all precautions, moisture may be absorbed by the transformer; and during the first few days of operation it is well to inspect the under side of the manhole cover for moisture. If sufficient moisture has condensed to drip from the cover, the transformer should be taken out of service and dried. The oil should be tested and dried if necessary.

Oil.—Samples of oil from all transformers should be drawn and tested at least once every six months.

During the first month of service of transformers having a potential of 40,000 volts or over, samples of oil should be drawn each week from the bottom of the tank and tested.

If at any time the oil should test below 16,500 volts, it should be filtered.

Inspection.—No matter how satisfactory the operation of a transformer may be, it should be taken out of service and thoroughly inspected at least once a year. See that the inside of the cover and the tank above the oil are clean and dry and free from moisture and that the thermometer bulb is clean. If an appreciable amount of dirt or sediment is found inside the case it is best to take the transformer out and remove the oil from the tank. The transformer and the tank should then be cleaned thoroughly and the oil filtered and tested. In cleaning, use only dry cloths or waste. See that all nuts are tight and all parts in their proper places. If the transformer is water cooled, clean the cooling coils thoroughly. Put the transformer and the oil in the tank again and when the cover is put on, see that all cracks and openings are closed tightly.

In the case of water-cooled transformers, the rate of flow should be checked from time to time and if it is found to have diminished the cause should be looked for and remedied. The most frequent cause of clogging of cooling coils is the presence of air in the water, resulting in the formation of a scaly oxide.

Removing Scale From Cooling Coils.—Scale and sediment can be removed from a cooling coil without removing the coil from the tank. Both inlet and outlet pipes should be disconnected from the water system and temporarily piped to a point a number of feet away from the transformer, where the coil can be filled and emptied safely. Especial care must be taken to prevent any acid, dirt or water from getting into the transformer.

Blow or syphon all the water from the cooling coil and then fill it with a solution of hydrochloric (muriatic) acid, specific gravity 1.10. (Equal parts of commercially pure concentrated hydrochloric acid and water will give this specific gravity.)

It may be found necessary to force this solution into the cooling coils. When this is done one end of the coil should be partially restricted, so that the solution will not be wasted when the coil is full. After the solution has stood in the coil about an hour, flush out thoroughly with clean water. If all the scale is not removed the first time,

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repeat the operation until the coil is clean, using new solution each time. The number of times it is necessary to repeat the process will depend on the condition of the coil, although ordinarily one or two fillings will be sufficient.

The chemical action which takes place may be very violent and often forces acid, sediment, etc., from both ends of the coil; therefore, it is well to leave both ends partially open to prevent abnormal pressure.

Idle Cooling Coils.—When a water cooled transformer is idle and exposed to freezing temperatures the water must be blown out of the cooling coil. In addition to blowing out of the water the cooling coil should be dried by forcing heated air through it. If not convenient to do this the coil should be filled with transformer oil.

Operation

An artificially cooled transformer should not be run continuously, even at no load without the cooling medium. Therefore, it is essential to maintain a proper circulation in the cooling system.

If the water circulation is for any reason stopped, the load should be immediately reduced as much as possible and close watch kept of the temperature of the machine. When the oil at the top of the tank reaches 80 deg. C. the transformer must be cut out of service at once. This temperature should be recognized as an absolute limit and must not be exceeded. It should be held only during an emergency period of short duration.

Nearly all cooling water will, in time, cause scale or sediment to form in the cooling coil. The time required to clog up the coil depends on the nature and amount of foreign matter in the water. The clogging materially decreases the efficiency of the coil and is indicated by a high oil temperature and a decreased flow of water, load condition and water pressure remaining the same.

Temperature. — Thermometers should be read daily (or more often), and if an oil temperature of 80 deg. or over for the self-cooled type is indicated or 65 deg. or over for the water cooled, the transformer must be cut out of service at once and the cause of the excessive heating looked into, for should the transformer remain in service any length of time under this condition, it may be badly damaged.

Regardless of oil temperature as indicated by thermometers, the transformer must not be operated at overloads not stipulated by the specifications or contract. When contract specifies an overload, a water cooled transformer operated at such overload should have the amount of water increased in proportion to the load. On account of the increased amount of water during overload the temperature of the oil will not rise as fast as the temperature of the windings and any of the causes leading to excessive heating will have more pronounced effect under these conditions. Therefore, the transformer during overload should be watched with especial care to see that the oil temperature is kept well below the temperature limits specified. Moisture may get into a transformer due to the fact that as oil is heated and cooled it expands and contracts and therefore air is expelled from and enters the transformer. If the air which enters the transformer is at the same time cooled off by contact with cover to below its dew point moisture will condense.

It is therefore good practice to operate transformers several degrees above air temperatures at all times. This will largely prevent condensation.

Distribution and Chord Factors

(Continued from page 344)

altogether the resulting pole-phase effect $v't'$ would be almost as great as xy from all six coils. Also in such a case the distribution factor would be represented by the expression:

(Line $v't'$*)* $\div$ *(Arc* vmt*)* which approximates 0.8 and is a much better figure than 0.636 with all six coils in.

This explains why the majority of single-phase motors are wound with *concentric* coils and the middle of the pole is vacant, or if a distributed winding is used about one-third of the winding is omitted in a suitable manner. When the motor is of the *split-phase* starting type, the slots left vacant by the omission of a part of the main running winding (for reasons just given) are utilized for the *phase splitting* or *starting* winding and are mechanically in the right position to make the starting winding 90 space degrees out of phase with the running winding, which makes the mechanical relation of the starting to the running winding similar to the two windings of a two-phase, polyphase motor. Such an arrangement is shown in Fig. 7, where the full lines represent coils in the main or running winding, and the dotted lines represent coils in the starting winding, which are cut out of circuit by the starting switch as soon as full speed is reached by the rotor.

A winding such as that shown in Fig. 7 may have a distribution factor of 0.8 or higher, when considering the running winding alone, whereas the winding of Fig. 8, where all the slots are filled with the running or operating coils, may have a distribution factor as low as 0.636 for the reasons explained in connection with Fig. 6. In the case of Fig. 8, starting is accomplished by a commutator and brushes, or in some way other than by the split-phase principle. In this winding, although the two middle slots are not needed for a starting winding, it would be an advantage to leave them vacant, as in this way perhaps 20 per cent of the copper in the stator winding can be saved and the electrical or magnetic effect of the winding would be very little less, being something of the nature of the length of the line $v't'$ in Fig. 6 as compared with the whole line xy.

Standard *diamond* coils of the type usually found in polyphase motors may also be used for single-phase. Such a winding is shown in Fig. 9 for a two-pole motor with twelve slots, having all slots filled and using all the coils for the running winding. In this figure the sides of the coils in the tops of the slots are shown in full lines, and the sides in the bottoms of the slots are shown in dotted lines. The *distribution factor* of such a winding would be low, being approximately 0.636 as explained in connection with Fig. 6. Here again, as in Fig. 8, it would be an advantage to omit the coils in the center of the poles and leave them vacant. Such a winding is shown in Fig. 10. With such an arrangement, if a split-phase starting winding was required on the same stator for some other job, the starting coils could be placed in slots 3 and 9 and 4 and 10.

One other feature of interest in single-phase distributed windings is the difference between *chord factor* and *distribution factor*. In Fig. 9 is shown a distributed winding whose coils *(Continued on page 371)*

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, July, 1923

Push! Pull! Or Get Out of The Way

IT IS said that the favorite motto of Jacob Kindleberger, president of the Kalamazoo (Mich.) Vegetable Parchment Company, is: "Push! If you can't push—pull! If you can't pull, please get out of the way!"

In every organization there are some who get ahead rapidly and there are others who wonder why. To those who wonder why Mr. Kindleberger's motto furnishes much food for thought. If you are a mechanic's helper or in charge of some particular work, there are plenty of opportunities to push or to pull and there are just as many opportunities to stand back and look on or knock the fellow who is pushing or pulling. But sooner or later you will look around to find someone saying, "Push or pull, or get out of the way!" and right there is your opportunity. If you don't push or if you don't pull—well, you'll just get out of the way, that's all!

Are You With a Wrecking Crew or Maintenance Men?

IN COMMENTING on maintenance work in one industrial plant, the superintendent referred to the men who handle emergency repairs as the "wrecking crew" and complimented them more as wreckers than "fixers," by adding: "And as often as not when they get through the machine is a wreck." Further investigation showed that in this plant only two qualifications were asked of these men: a strong back and the ability to fix anything, which in this case really meant "a desire to tinker and see what will happen."

Equipment, especially electrical equipment or highly complicated, specially designed production machines of the present day, is not fixed by the "tinkerer" of yesterday. He can easily make a mistake due to ignorance of the principles on which the mechanism operates, which will mean expensive repairs in addition to a shut-down which is perhaps more expensive in every way.

Men better qualified for the work—those with mechanical experience, such as all-around mechanics or men with a good working knowledge of electricity in its practical application to and operation of equipment—will, with an appreciation of their services, strive harder to make maintenance work a real thinking job. Men who think before they act like to be credited with applying their ideas; they want to be recognized as real maintenance men and not wrecking crews. It is difficult to have a higher appreciation of one's work than those in higher responsible positions credit to it—and right here a lesson can be taken to heart by those who supervise the men who do maintenance work.

The Foreman as a Teacher

EVERY successful foreman is a teacher whether he knows it or not and the one thing that contributes most to his success in the handling of men is his teaching instinct and ability. If you stop to think a little you can probably recall a mechanic or electrician who became so expert in his work that he was made a foreman. But simply because he did not have the patience to train beginners and others who knew less about the work than he did, he was soon relieved of his foremanship job or left to take another position.

Then there is the fellow who has the patience to show the beginner, but in showing him how to lay out or set up a job he does all the work himself and asks the beginner to watch him, without pointing out the steps in the work and explaining the many things that may happen if an error is made in any one of these steps. In such a case when the beginner makes a mistake he may be cussed out for it and commanded to keep his eyes open this time as the expert goes rapidly through the operations again. Such a foreman simply scares a young beginner and sets up a fear of doing something wrong that prevents the asking of questions that may bring a reprimand.

Then there is the third type of man, the one who makes the successful foreman—the man who remembers the troubles he went through as a beginner and knows how to combine telling and showing over and over again with a smile and some such remark as, "Try it again, my boy, and if you get stuck come to me and I'll help you out. When you have done this job as many times as I have you will be able to show me a better way to do it." Such a remark not only inspires initiative and confidence but trains a beginner to think. If he can be made to see the importance of thinking out each operation before he actually does it and avoid the "monkey-see-monkey-do" tendency, the foreman has solved the great secret of teaching and training workmen.

The next essential in teaching is observation on the part of the foreman to see how much the beginner absorbs when performing each step of a new job. One man can absorb and remember more than another and the foreman's big job is to see that he gets at least one thing right at a time and keeps on adding one thing after another so that he can be left to work out other similar details for himself in a reasonable length of time. But in every case it is the job of the foreman to continually drop the hows and the whys in the right place, for the things that are simple when you know

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how and why to do them are not so apparent to the one who is starting in to do a kind of work that is entirely new to him.

Teaching has been called an art. In a workshop it is a great asset in a foreman for it reduces waste and increases the production of men as no other single thing can do. In a works where every job is done correctly and the foremen know how to bring this about, these foremen are the reasons for a successful shop and profits that pay good wages. On the other hand, those foremen who are known as crabs and walking evidences of irritation and poor digestion when things go wrong—and they go wrong frequently—these same foremen are one of the reasons for complaints from executives regarding high production costs and troubles with apparatus that is produced.

If you are a foreman think this over and study your job and your methods. Perhaps all that stands between you and a big job is a little more patience as a teacher and a little more thinking on your part as to how to make yourself a better teacher and get your men to come to you with their troubles. Just remember that you were a beginner once and appreciated a friendly tip from an experienced fellow-worker.

Decrease in Fire Loss of Electrical Origin

THOSE readers of INDUSTRIAL ENGINEER who take pride in doing a good job, will note with satisfaction an important decrease in the amount of fire loss attributed to electrical causes. Since the first introduction of electricity it has been cited as a fire cause of major importance, and rules to control its hazard were first established in 1881. These early rules have been improved upon and standardized and are now a part of the National Electrical Code. However, in spite of progressive improvements in electrical equipment and methods of installation, the annual losses reported as due to fires of electrical origin continue heavy. However, no complete loss analysis figures were available prior to 1915. In the period from 1915 to 1919, according to the National Board of Fire Underwriters, the loss from fires of electrical origin was over $84,000,000 or an average of nearly $17,000,000 per year. During this time, fires due to electrical causes, were the largest item among the classified losses due to known causes and amounted to about 15 per cent of the total, excluding those of unknown origin or those due to exposure and conflagration. Of course some fires were wrongly attributed to electrical causes purely on guesswork or inability to determine the real cause.

In the 1920 fire loss figures, as recorded by the National Fire Protection Association, "matches and smoking" displaced electricity as the most important fire cause. According to the 1921 statistics, electricity had taken fifth place with a total loss of $12,723,000, or a decrease of over $4,000,000 from the 1915-19 average. In addition, it is now responsible for only 8 per cent of the total loss as compared with 15 per cent of the loss for the earlier period.

That this loss has decreased in spite of the extensive increase in the use of electricity is in no small way attributable to the greater care exercised in the installation and supervision of electrical equipment and distribution lines. Pride in good workmanship in installation is no small factor in making this decrease.

The Best Cure for Trouble Is to Prevent It

IN THIS issue an article on page 348 gives some practical details on the care and operation of transformers from the standpoint of those who have charge of their installation and maintenance. These instructions have been compiled by the Transformer Section of the Electric Power Club—an organization of electrical manufacturers that has for its object the standardization, improvement of production and increase in distribution of electrical apparatus.

In these instructions one point is brought out that is frequently overlooked by men in charge of operation. This is that the successful operation of a transformer is as much and perhaps more dependent upon proper installation and maintenance than on proper design and manufacture. The works of a transformer are enclosed in a metal case and at times the things that go on inside that case while in operation, for instance during a thunderstorm, are often beyond the conception of the skilled transformer designer. But so long as there is voltage on the secondary winding the usual inference is that everything is O. K. And not until serious trouble shows up is that piece of electrical equipment given much attention.

In the case of rotating apparatus this is not the case for signs of trouble can more easily be seen and even small troubles are watched and remedied at once. The same kind of attention should be given to a transformer and this attention should be directed toward location, handling, installation, inspection and testing of oil, and manipulation of loads put on transformers. These points are taken up in this article in such detail as will help to train men to get the best possible service from this apparatus with the minimum of trouble and work.

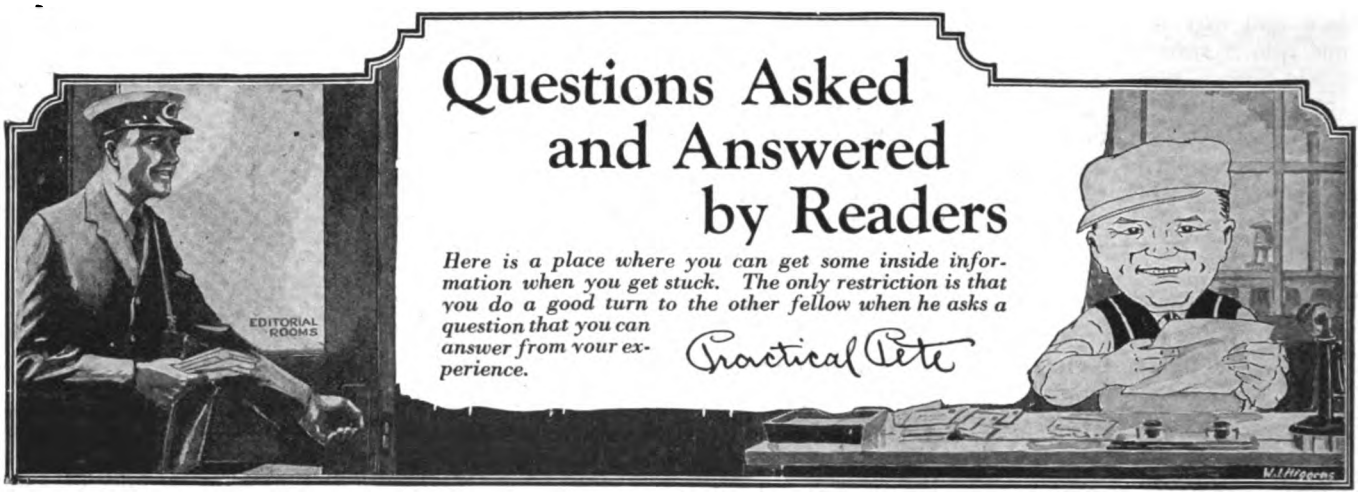
Is It a Sign of Weakness to Seek Information?

WHEN trouble is traced back to the real cause it is altogether too often found that somebody tried to apply new equipment or methods without a clear knowledge of the limitations or modifications necessary for that particular service condition. This is partially due to an antiquated idea, which unfortunately still exists among many industrial men, that to ask questions is a sign of weakness. Rather, the ability to ask sensible questions is a good sign of balanced judgment.

In working up the article on "Types and Kinds of Chain Drives," which begins on page 335 of this issue, almost every manufacturer engaged in supplying chain drives urged that prospective users co-operate more closely with their engineering and manufacturing departments in the selection of the proper width, pitch, number of teeth in the sprockets and the other specifications for a particular job.

Investigation of several disappointments in chain-drive installations has shown that they were in a large measure due to industrial men applying a chain drive to service conditions to which that particular size and pitch was not adapted. Advice could have been obtained quickly from the manufacturer or his local representative and this grief and distrust in the equipment eliminated. It is easier to ask questions—and much cheaper—than to depend wholly upon experience.

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Who Can Answer These?

Preventing Corrosion of Copper—Will someone please tell me how I can prevent the corrosion of copper parts of equipment that is located in a chemical plant. I have tried everything I can think of, but without success.
Charleston, W. Va. E. B. G.

* * * *

Rewinding Single-Phase Motor—I have a single-phase Menominee motor that has a main winding of 29 turns of No. 19 wire with two wires in parallel in slots 1 and 7. There are 48 turns in slots 2 and 6 and 49 turns in slots 3 and 5. This is a 4-pole machine.

The starting winding has 12 turns of No. 25 wire in slots 1 and 7; 20 turns in slots 2 and 6, and 20 turns in slots 3 and 5. What I want to know is whether or not this motor can be wound with a single wire and what size will be required to replace the two No. 19 size in parallel. The motor has 24 slots and the nameplate shows 110 volts, 3.8 amp. 1/6 hp., 1750 r.p.m. I have just rewound one of these motors with a single No. 19 wire and it seems to run all right.
Sartell, Minn. L. S.

* * * *

Connecting Lights and Small Motors to the Same Panel Board—I would like to get an expression from readers of INDUSTRIAL ENGINEER as to their experience in connecting lights and fractional-horsepower motors to the same panel board. In our plant the incoming feeder is three-wire, three-phase, 110 volts a. c. We have five lighting circuits of approximately 600 watts and we have six motor circuits with a motor connected to each operating a ventilating fan. The motors are single-phase with the following ratings: two ⅛-hp., three ¼-hp. and one 1/16-hp.

I would like to see a diagram of a panel board arranged with a double bus to connect lights and motors separately, or any other arrangement which may be considered satisfactory. Please also indicate the way these circuits should be fused and the arrangement of switches for individual control.
Seymour, Conn. W. N.

Rewinding Universal Motor—I would like to rewind a Universal motor for three phases, 60 cycles, 220 volts, which has the following nameplate data: Type D, single phase, No. 14,840, 3,600 r. p. m., 220 volts, 60 cycles, 2 amps., ¼ hp. The motor has 24 slots and 8 coils of 56 turns of No. 19 B. & S. wire for the running winding. The other slots were used for the starting winding. What will be the size of wire, turns per coil and coil span for the new winding when operated three phase? There is very little end room so the coil span will have to be as small as possible. Please show how to figure out this winding and give a diagram.
Kimberley, Wis. H. D.

* * * *

Derivation of Chord Factor—(1) In his answer on rewinding a motor for four speeds, A. C. Roe says, on page 212 of the April issue: "Assuming a 1 and 12 pitch the chord factor is .99144. . . . . Then the voltage per turn for full pitch will be (127x1.009) divided by 104 . . . . . For a 1 and 10 pitch the chord factor is .92388, and full pitch voltage per turn equals (127 x 1.076) divided by 104 . . . ." I should like to know how the values 1.009 and 1.076 are derived, as the chord factor differs from the values given.

(2) In A. M. Dudley's book, "Connecting Induction Motors," there is given on page 187 the output coefficient values for 4, 8, 10, 12, 16, 20 and 24 poles. What values should I use for 2, 6, 10, 14, 18 and 20 poles?
Santa Barbara, Chihuahua, Mex. F. R. G.

* * * *

Rewinding Motor with Basket-Shape Coils—I shall appreciate it if some reader will give me some information about changing a motor winding. This is a Westinghouse motor, type CCL, 10 hp., 1420 r.p.m., 220 volts, 25 cycles, 3-phase, style No. 137022 A, serial No. 1585893. This motor was rewound with the so-called concentric winding and has eighteen coils of thirty turns of No. 13 wire, two wires in parallel, connected two circuit star. It is very difficult to rewind these motors with a concentric winding wherein the coils are wound full pitch. What changes would be necessary to wind this motor with basket-shape coils, reducing the coil throw and changing the connections?
Joplin, Mo. R. A. F.

Answers Received To Questions Asked

How to Figure Ampere Rating of a Cable—How can I find the rating of a cable when I know the number of wires in the cable and the size of these wires? For instance, what is the rating of a cable that is made up of seven No. 14 wires?
Sartell, Minn. L. S.

The following will answer the question by L. S. in the March issue of INDUSTRIAL ENGINEER on how to figure the ampere rating of a cable. Referring to a table of allowable carrying capacities of copper wire, it is found that the area of No. 14 wire is 4107 circ. mils. Multiplying this by 7, the number of wires in the cable, we get 28,749 circ. mils. The table shows that No. 6 wire has an area of 26,250 circ. mils, and has a current rating of 50 amp., therefore, the cable has a rating of 50 amperes.
Boston, Mass. L. B. MORRILL.

* * * *

In reply to the question by L. S. of Sartell, Minn., in regard to the current rating of cables, I wish to call his attention to tables I and II, rule 18, of the National Electrical Code, where it is shown that the current ratings of stranded wires in table II are the same as the nearest equivalent solid wires.

Seven No. 14 wires make a cable with an area of 28,749 circ. mils, which is, of course, the sum of the areas of seven No. 14's each of 4107 circ. mils. The nearest equivalent area in solid wire is that of No. 6; consequently the current rating is the same as No. 6 solid wire.

This applies also to other sizes. For example, a cable consisting of 19 strands of No. 14 has a total area of $19 \times 4107 = 78{,}030$ circ. mils. The nearest equivalent in solid wire is No. 1 with an area of 83,690 circ. mils. and a current rating of 100

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amp.; consequently, the 19 strands of No. 14 make a No. 1 cable with a current rating of 100 amp.

As the table of current ratings of solid and stranded wires are read down, it will be noted that they are practically the same for wires down to No. 0, and nearly the same for all others. E. A. GIBBS.

Boston, Mass.

* * * *

Trouble with Motor Generator—We have a 175-kva. motor generator set which is giving us trouble. The motor is a synchronous type operated at 2,200 volts. The generator is direct connected and produces 250 volts, d. c. The trouble we are having is with the a. c. motor. The stator and rotor of this machine have been rewound six times during the last year and a half. It carries a load of about two-thirds capacity but must and does handle 50 per cent overload for about two minutes over fifteen-minute periods. The generator is handling a load of mine locomotives and the overload occurs when the locomotives are taking the crest of a grade. However, the temperature rise of the machine at the end of a day's run is not higher than allowed by the manufacturer. The machine seems to be O. K. until it lets go, there being no evidence of slowing down. So far as we can ascertain, it seems as though the pole face winding gives way and this rips up both stator and rotor. The d. c. generator will not over-compound, even with all the shunt field cut out. I would like to see some explanation of the cause and remedy for this trouble.

Vincennes, Ind. T. J.

It occurs to me that T. J.'s trouble with his motor generator, as mentioned in the February issue, is similar to my experience with a 200 hp. synchronous motor operating at 2200 volts. This motor is used for a stamp mill drive, and is started by means of a 35-hp. induction motor and then thrown on the line with an automatic synchronizer. This motor carries about three-quarter load and the balance of its capacity is utilized for power factor correction and care is exercised to limit the machine current to the normal full-load current for the motor.

Following a burnout, an examination of the stator winding revealed several grounds at the point where the coils entered the laminations of the frame. A great majority of the coils were badly bent at this point, due to inadequate mechanical support. It was found that the automatic synchronizer did not function when the machine was in exact synchronism with the line, thus imposing a heavy strain on the motor windings and causing them to be bent at their weakest point, with consequent breakdown of the insulation.

More adequate support was given to the stator winding in the form of very stiff slot tubes, which protruded several inches from each side of the laminations. A more rigid binding of the winding and proper adjustment of the automatic synchronizer has prevented further trouble.

From T. J.'s description of his trouble, it would seem that the motor was subjected to occasional strains, rather than continuous overloading, which in time broke down the winding. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

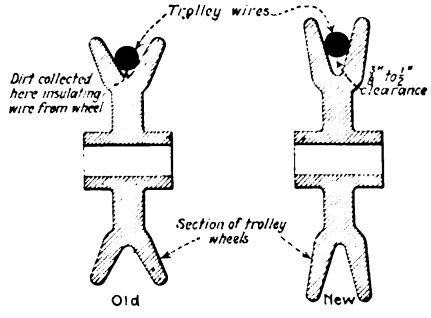
* * * *

Crane Collector Wires—On a five-ton alternating-current crane, having a bridge or cross travel of about 50 feet, we have experienced considerable trouble with the collector wires sparking at the contacts. Both types of collectors have been tried out; namely, shoes and wheels, and we have been forced to use flexible cables to do away with standard collecting devices.

Can readers tell us what the trouble is and how they overcome such difficulties in practice, for we do not feel it should be necessary to resort to the method we have adopted?

New York, N. Y. M. K.

In the February issue I noticed the answer to a question by M. K. concerning trouble with a 5-ton alternating-current crane not getting the proper contact between the collector wire and the shoes or wheels. It reminded me of my experience with our a.c. foundry crane. I had trouble with the trolley wire and



How a trolley wheel was redesigned to improve the contact.

wheels day in and day out and finally discovered that the trolley wheel had collected a considerable amount of dirt which insulated it from the trolley wire. This was remedied by building a pattern and making a cast-iron deep-V wheel with about 3/8 in. to 1/2 in. clearance between the wire and the bottom of the V-groove in which the trolley wire runs. This put an end to all trouble. The deep groove allowed room for dirt so that it did not insulate the wire from the wheel. Also the wire crowds down into the groove thus keeping the sides clean.

Medina, Ohio. CARL NEWBRANDER.

* * * *

Contact Points on Electric Bells—What is the best metal other than platinum, to use for contact points on electric bells and gongs? If several kinds can be used, will you please indicate the order of their suitability, as first, second, third, etc.?

New Orleans, La. P. B. A.

In the May issue, P. B. A. asks what metals other than platinum may be used for the contacts of bells, gongs, and other instruments.

I have found that coin silver makes an excellent contact metal and in many cases is preferable to platinum. A small piece of silver wire about the size of No. 14 B & S gage can be purchased and when it is desired to make a contact point a very short piece can be placed in the hole in the contact spring and headed down on both sides. This will give an excellent contact for any kind of instrument. PERCY A. BLAISDELL.

Everett, Mass.

* * * *

Location of Starting Equipment for Synchronous Motor—We are about to install a 350-hp. synchronous motor on a circulating pump. Would it be practicable to install the starting equipment about 100 ft. from the motor at the main switchboard, although the man starting the motor would not be able to see it? However, a man standing about 25 ft. from the motor could easily signal the operator. The main switchboard is on a gallery above the motor and if possible we would like to have the switchboard operator handle the starting and stopping of the pump.

Hudson, N. Y. F. R.

With reference to the question by F. R. in the March issue, we would recommend by all means, that the operator be able to see the motor which he is starting. If you will give the matter a little thought it becomes evident that when starting large machinery various things may happen; so it finally becomes a question of safety and therefore a little expense should not be spared in arranging for the operator to have full vision of the machine which he is controlling.

We assume from the questions and from the information given that the starting equipment is manually operated, or in other words that it is not automatic control. If it were automatic control it would become a simple matter, inasmuch as the comparatively small control wires can be run to any desired point. However, if the motor is manually operated,

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the power wires of necessity have to be run to the point where the starter is situated. Even so, we recommend that the starting equipment be arranged so that the motor is visible to the operator.

Automatic starting equipment for synchronous motors has been of late highly developed and we suggest that such equipment be seriously considered as it has many advantages over the manually-operated type. For instance, the control stations can be placed at any desired point inasmuch as it is not necessary to run the heavy power wires to these stations. There are also those features in automatic control which provide for absolute protection for the machinery and the operator, which cannot be had in manual control unless, of course, the operator is highly trained and knows the characteristics of the machines which he is operating.

Allen-Bradley Co., Milwaukee, Wis. W. PFEIFER.

* * * *

Why Does This Motor Reverse?—What would cause a 2-hp., d.c. compound motor, when a heavy load is thrown on, to reverse its direction of rotation? It can be started in one direction and then stopped and the next time it is started it may run in the opposite direction.

Toronto, Canada. J. H. M.

In answer to J. H. M.'s question in the January issue relative to a motor reversing when a heavy load is thrown on it, I believe that the field windings are differentially connected. When a heavy load is thrown on the machine a relatively heavy current flows through the series field winding, and if the differential connection exists, the flux produced by this heavy current becomes greater than that due to the shunt field winding and reverses the magnetism. This would cause the motor to run in the reverse direction. If it is now stopped and again started, lightly loaded, it will again reverse its rotation after the shunt field windings are differentially connetism to its former polarity.

I would suggest reversing the current through the series field so that the flux produced by both windings will aid each other, or, in other words, connect the motor cumulative; or a shunt could be connected around the series winding, obtaining the correct resistance by trial. In the latter case the motor would have characteristics resembling a shunt motor. I. J. GRONVOLD.

Tacoma, Wash.

The trouble with the compound motor mentioned by J. H. M., Toronto, Canada, is that the series fields and shunt field are connected so that they oppose each other. It will run in the direction the shunt field influences it while starting, but as soon as the heavy load is applied the series field picks up and overcomes the shunt winding effect and changes the direction of rotation.

Try disconnecting the shunt winding, then starting the motor with the series field only to note the direction of rotation it tends to give the motor. Be very careful not to let your motor run away. Just let it start and no more. No doubt you will find it tends to run in the opposite direction to what it did when starting with the shunt field connected.

Reverse the shunt field so that both windings are working together and reverse the armature if the motor should run the wrong way. Make this change and I am sure that your troubles will be over. I hope I have been of service and may need a hand from you some time.

Charleston, Wash. H. MCCONVILLE.

* * * *

The following will answer the question by J. H. M. of Toronto, Canada, as to why a d. c. compound wound motor will reverse when a heavy load is thrown on. The reversal happens because the motor is differentially compounded; that is, the shunt and series field instead of working together are working against one another and when a heavy load is thrown on the motor, the series field sets up a stronger flux than the shunt field. Therefore, the resultant flux, which determines the rotation of the armature, is in the opposite direction and the motor runs in the opposite direction.

This may be easily overcome by reversing the leads of the series field, which will reverse the direction of the current relative to the field, thereby causing the two fluxes to be in the same direction and the shunt and series fields will work together and give the proper characteristics of a compound motor.

NORMAN E. SMITH.

New York Shipbuilding Co., Westville, N. J.

* * * *

In regard to J. H. M.'s question in the January issue as to what makes a compound d. c. motor reverse on overload or at starting, he will probably find that the motor in question is differentially compounded. In that case a sudden load or a load at starting would cause the motor to reverse its direction of rotation especially if it is over-compounded.

The following procedure will reveal whether or not the motor is differentially connected. Start the motor up without load and while it is running open the shunt field. If it is differentially wound it will reverse its direction of rotation and run in the opposite direction at high speed. One must be careful in making this experiment to stop the motor at once as it will then be running as a series motor without load and a series motor without load will "run away."

If the motor is found to be differentially wound, the cure for the trouble will be to reverse the connections to the series field so the motor will be connected as a cumulative winding. This, of course, will change its characteristics slightly but the motor will operate all right.

D. A. BLODGETT.

Chevrolet Motor Co., Flint, Mich.

* * * *

In answer to J. H. M. regarding the reversing of a 2-hp. compound motor will say that I have had the same trouble and stopped it by reversing the series field leads, as the fields were bucking each other. On light loads the trouble did not show up, but with a good load on the motor would accelerate to about half speed, throw the belt off and race as an unloaded series motor.

H. G. LEONARD.

New Haven, Conn.

* * * *

J. H. M. desires to know why a 2-hp. compound-wound motor reverses its direction when a heavy load is thrown on. This is without a doubt due to the series fields bucking the shunt fields. The motor should be tried as a plain shunt wound motor and if this works alright, then reverse the compound or series fields and try it again. It is possible that only part of the series coils are opposed to the shunt winding.

To test the polarity of the fields first place a suitable amount of resistance in series with the compound fields and note the pole of a compass that each field attracts when the current is shunted across them. Then put the shunt fields across the line and check them with a compass. The shunt and series fields should agree as to polarity.

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If a compound lead is taken for the line connection on the motor, care should be taken that the shunt, taken with the other lead to connect to the armature, comes from the same side of the same field. In our experience we have found that compound-wound motors will not always work properly with the compound lead for the line. The most successful way is to connect a compound and a shunt lead coming from the same part of the same coil for the line and then connect the other side of the compound to the armature. The other field and armature leads then go to the rheostat.

Peoria, Ill. GEORGE D. RINGNESS.

* * * *

With reference to the question by J. H. M. in the January issue of INDUSTRIAL ENGINEER, the reason the compound d.c. motor reverses under heavy load is that the series field is opposing the shunt field. When starting at practically no load, the shunt field provides the necessary field for the desired direction of rotation, but when fully loaded the series field provides a greater flux in the opposite direction and counteracting the shunt field flux, causing the reversal of the armature. If you reverse the series field connections you will experience no further trouble. E. H. LAABS.

Cutler-Hammer Mfg. Co.,
Engineering Department,
Milwaukee, Wis.

* * * *

In answer to the question by J. H. M., Toronto, Canada, as to the cause of a compound-wound motor reversing its direction when a heavy load is thrown on it, I will say that there are two kinds of compound-wound motors. One is differential wound, the other cumulative wound. I think he is speaking of the first type because it is extensively used.

The differential-wound motor has two sets of fields. The shunt field has a constant supply of current and is connected across the supply lines; the other, series field, is connected in series with the armature and has a magnetizing effect depending upon the pull of the armature or load applied to the motor.

It is clear that the current in the series field is reversed and opposed to the magnetizing effect of the shunt field. As the load is applied the magnetizing of the shunt field will be weaker than if the shunt field was alone. Then, if you now have a weakened shunt field because of shorts in the winding, bad connections in field or rheostat, or a complete open after the motor was up to speed, this would cause the motor to reverse its direction because just as soon as the series field has enough current to overcome the magnetizing effect of the shunt field, it will reverse itself. The weaker the shunt field, the more current the armature must have, therefore, the series field will be the stronger.

The motor also could be over-compounded; that is, it would have too many turns in the series field.

Chief Electrician, H. T. FOX.
G. & J. Tire Co.,
U. S. Rubber Co.,
Indianapolis, Ind.

* * * *

I have found two instances similar to the one related by J. H. M. where the trouble was due to poor contact at field terminals on the starters. However, the trouble may also be the result of wrongly connected fields; that is, series and shunt fields have opposite polarities.

To test for this condition disconnect one side of shunt field, run as a series motor, and note direction of rotation. Do not cut out the starting resistance as the motor will overspeed. Now open the connection between armature and series field, reconnect the shunt field across the armature and start the motor. If rotation is reversed, the fields have opposite polarity. To remedy this cross either shunt or series connections whichever will give the desired direction of rotation.

Another way would be to take the speed of the motor compounded and then short circuit the series field and take the speed again. If the speed decreases, the fields are of opposite polarity.

It seems to me that if proper size fuses were used they would blow before the motor could reverse while heavily loaded. N. G. WILLEN.

Crocker-Wheeler Co.,
Ampere, N. J.

* * * *

J. H. M. wishes to know what causes his compound-wound d.c. motor to reverse its rotation under heavy load. This is most likely caused by the series fields being connected up to give an opposite polarity to the shunt fields. Of course under a light load there is very little current passing through the series coils and the polarity will not be affected. The current will, however, tend to deaden the shunt field, causing the motor to run above normal speed.

When a heavy load is put on the motor the series field is strengthened and overcomes the effect of the shunt field, changing the polarity of the field and, therefore, running the motor in the opposite direction.

The series field leads should be changed or swapped around where they are connected on the outside of the motor, without changing the other leads. If this cannot be done, owing to the series field leads not being brought outside of the motor, change the shunt leads around, outside of the motor and also change the armature leads where they are connected on to the brush holder studs. ELLIOTT M. GASKILL.

Foreman Electrician,
Wharton, N. J.
Mt. Hope Mines.

* * * *

NOTE: These several answers to the question by J. H. M. are presented because of their general agreement on the possibility of the shunt and series fields being of opposite polarity as now connected. And also because two or three refer to other points that are worth trying out at the same time the polarity is checked.—PRACTICAL PETE.

* * * *

Changing Speed of Single-Phase Motor—I have recently had trouble with a single-phase, 3-hp., 1200 r.p.m. motor which was marked Variable Speed on the nameplate. This motor has four brushes, two on compensating winding and two on the main winding, but seems to be a six-pole design. I would like to know how this motor can be changed to get a variation in speed.

Kings Park, N. Y. N. J. W.

From the question by N. J. W. of Kings Park, N. Y., it is evident that his motor is a repulsion induction motor of the brush-shifting type. It is probably a General Electric type B. S. S. motor. Of the four brushes, two are energy brushes and the other two are compensating brushes, which are connected to the compensating winding. It is necessarily a 6-pole design to obtain a synchronous speed of 1200 r. p. m.

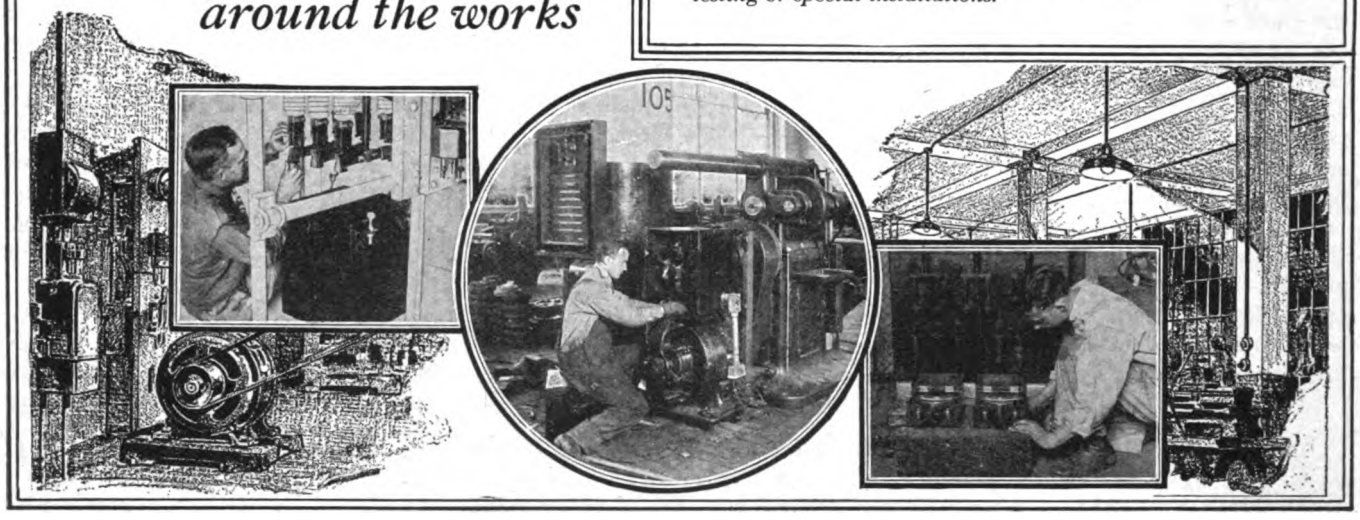
The speed may be varied by loosening the brush yoke and shifting the brushes. A minimum speed of 600 r. p. m. at full load can be obtained. If this is a General Electric motor, the proper instruction book, which will give more complete information, may be obtained by writing to the nearest office of the General Electric Company. L. B. MORRILL.

Boston, Mass.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Easily Constructed Portable Staging Facilitates Work on Overhead Equipment

A PORTABLE staging which we have used for several years when painting or doing electrical or millwright work, has saved so much time and been so useful that it may be of interest to the readers of INDUSTRIAL ENGINEER. As will be seen from the accompanying illustration the lower part of the first staging we made up was built of 2¼-in. seamless steel tubing, 7/32 in. thick, welded into malleable iron fittings. The upper part, which telescopes into the lower part, so that it can be raised or lowered as desired, was made of 1 15/16-in. seamless tubing 7/32-in. thick. Later it was found that black pipe could be used in place of the seamless steel tubing with equally satisfactory results.

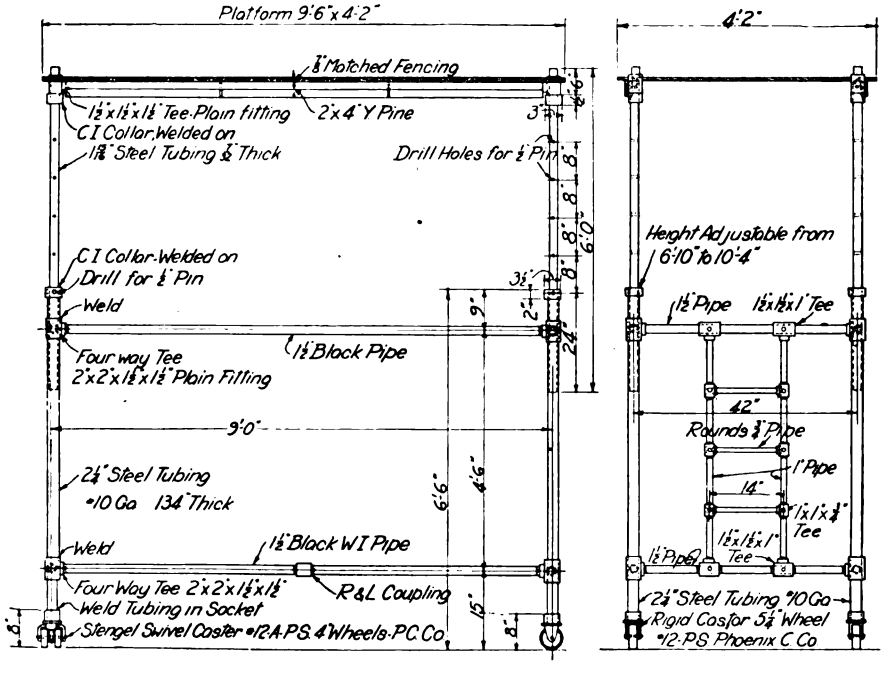
Holes large enough to take a ½-in. pin are drilled on 8-in. centers in the supports of the upper part of the staging to allow the platform to be set at any desired height. The platform at the top is made of ⅞-in. matched fencing, nailed onto pieces of yellow pine 2 by 4. It is made in three sections, which can be removed. The bottom rail is made of two pieces of 1½-in. pipe put together with a right-and-left-thread coupling. When working above machines this rail is taken out to allow the staging to straddle the machines.

The ladder at the end consists of ¾-in. pipe for the rungs and 1-in. pipe for the sides, screwed into malleable iron T's.

This staging is not expensive to make and is well worth its cost, as it permits overhead work to be done with the maximum of convenience and safety. L. B. C.

La Salle, Ill.

This staging furnishes a safe standing place for the installer or repairman.



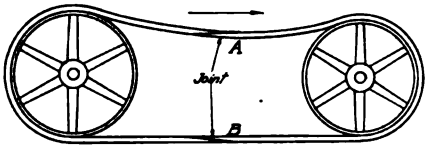
Experience Shows How to Arrange Laps of Cemented Joints in Belts

WHEN the joint of a belt is to be cemented there is often a question as to the direction in which the laps of the joint should point. Common practice is to arrange the laps as shown in *A* of the illustration, so that the inner lap will point opposite to the direction in which the belt is to be run. The object of this is to prevent all possibility of the inner lap rolling up, which it might do if it met the pulley point on.

But with the inner lap so arranged, the outer one must point in the running direction. Consequently, when the joint is passing over a pulley and the outer lap is subjected to a bending stress which tends to open it, the point of the lap is running against the pressure of the air and is thus subjected to a disrupting force which may be greater than that which is due to friction against the face of the pulley. Hence, pointing the inner lap

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in the running direction, as in *B*, would seem to be the better way. The superiority of this method was shown in the case of a 30-in. main



The question is often raised as to the direction in which the laps of cemented joints in belts should point. In the text there are given the results obtained with a belt having two joints in which the laps pointed in opposite directions.

belt running 3,500 ft., or nearly 0.6 of a mile, a minute. This belt contained two cemented joints. In one joint the inner lap pointed in the running direction. This joint never gave trouble. For some reason the other joint was made with the inner lap pointing away from the running direction. It was necessary to remake this joint frequently on account of a tendency of the outer lap to work loose and peel off.

St. Louis, Mo. A. J. DIXON.

Simple Method of Mounting Starting Equipment for Motor on Column

WHEN a motor is located near a building column the latter can often be used to advantage for mounting the starting equipment in a very satisfactory and neat manner.

The photograph shows the method of mounting the control for a 50-hp. 440-volt, 900 r.p.m. slip-ring motor driving an air compressor. The 100-amp. line switch is mounted in a box directly over the drum controller on one side of the column. The feed to the switch box comes in an overhead conduit to the top of this box. The controller is mounted far enough away from the column to permit easy access to the terminals and allow sufficient room between the controller and the column for the conduit carrying the stator leads to pass behind it. The starting resistance is mounted on a side of the column at right angles to the controller, with the connection side of the resistance toward the connection side of the controller. This permits of a short connection, which requires no support, between the controller and the resistance. The rotor leads tap into these leads between the controller and resistance.

EUSTACE C. SOARES.

Electrical Engineer,
Ophuls & Hill, Inc.,
New York City.

Tests Made on the Use of Special Motors to Drive Fluctuating Loads

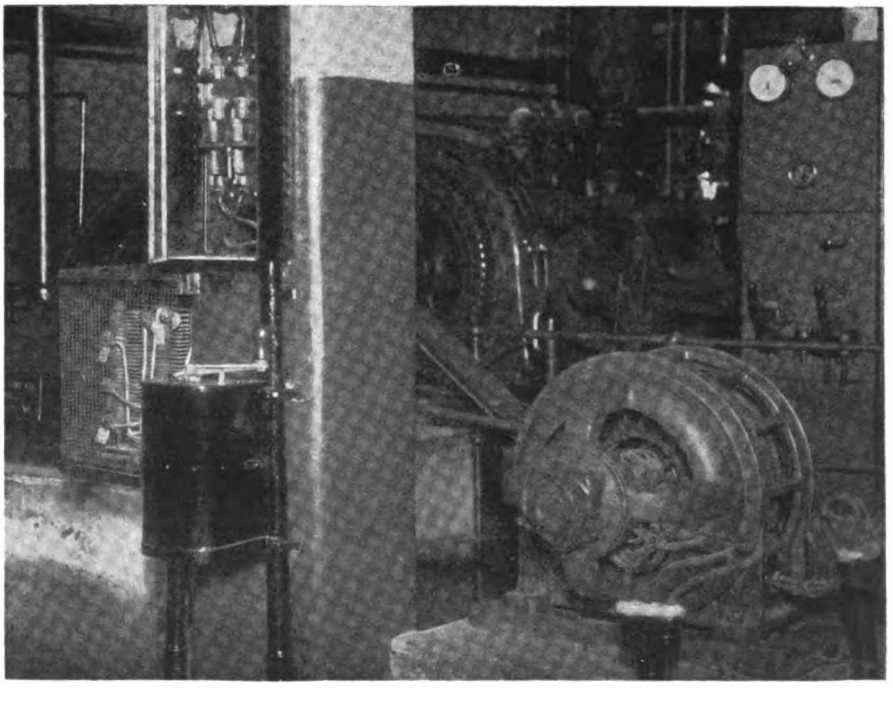
A MACHINE which has a fluctuating demand for power calls for special care in selecting a motor to drive it. The ordinary motor may not give the best results. It is often possible, however, to use motors with special features which will give very good operation.

These facts are particularly applicable to direct drive with alternating-current motors. There are many machines such as presses, punches, and so on, whose loads vary rapidly. Such loads as these can often be satisfactorily driven by an induction motor having a rotor with resistance higher than that of the ordinary rotor.

A very good example of such an installation is the motor driving a press from which the accompanying curves were taken. This drive shows the advantage that comes from the higher resistance in the rotor. The press mentioned is a Stohl press used for making 7-ft. fence posts of 14-gage material. Tests were made using an ordinary motor and a motor with higher resistance in the rotor. The two curves show the results. A 20-hp. motor was employed in each case and the press was doing exactly the same kind of work.

The curve at the left shows the variation in power when the press is operated by a motor of the ordinary low-resistance-rotor type. Reading the chart from right to left, it will be noticed that the normal, light load power is from 2.5 to 5 kw. When the clutch is thrown in, however, the power rises suddenly to about 25 to 30 kw. and drops back with equal suddenness to light load again. At the working stroke the power again rises, this time to about 37 kw., and again drops to normal almost instantly. It is evident that the motor is bearing the full strain of the load. For all practical purposes the flywheel might as well not be there. This is seen from the fact that the input to the motor rises and drops so suddenly. When the load comes on the motor its speed does not drop very much. This is true because the ordinary squirrel-cage motor is practically a "constant-speed" machine and does not slow down markedly with increased load. For this reason the flywheel on the press cannot help much in doing the work over the peak-load period.

Contrast this curve with the one at the right, in which the power demand of a motor with a high-resistance rotor is shown. The total work done is naturally about the same, but it is far more evenly distributed, and therefore the operation is more satisfactory. On throwing in the clutch the speed of the motor decreases



Here is a good installation—and a good way of utilizing a building column. The starting equipment is convenient yet mounted far enough away from the column to permit easy access to the terminals and allow sufficient room for the conduit.

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momentarily, thus reducing the shock of engagement. The power demand, instead of rising to 30 kw., rises to about 7 kw. Moreover, on the working stroke the motor again slows down, thus compelling the flywheel to perform its proper function of shouldering the peak load, and so doing its share of work with a striking reduction in power. The motor then rapidly accelerates the flywheel and restores its momentum ready for the next working stroke. Since there is ample time to do this before the next piece of work can be fed into the machine, no disadvantage is involved, and violent strains to the motor and press are avoided. The higher resistance motor used in the test described was made by the Lincoln Electric Company. This company has made a study of such drives and the results obtained from the application of various amounts of resistance in the rotor.

With the lower peak loads which are present with the higher-resistance rotor, there are other advantages. In the first place many power companies object to a rapidly fluctuating load. Sometimes they measure the maximum demand and put on an additional rate corresponding to the magnitude of the demand. Another advantage is that smaller conductors may be used in the motor circuit. This is especially important if the circuit is long and will consequently have a large voltage drop.

Of course this type of motor does not solve every direct-driving problem. The ordinary type of motor is often suitable for direct coupling to the machine it drives. Some factory equipment, such as centrifugal pumps, sandblasters, and so on, starts on comparatively light load, and for these the ordinary motor is quite suitable. Others, such as beaters in paper-mills, require considerable power to start them from rest, but once started the load is fairly constant. For such work the slip-ring type is eminently suitable. But there are many other machines besides presses for which special motor types should be used if the most satisfactory operation is to be obtained.

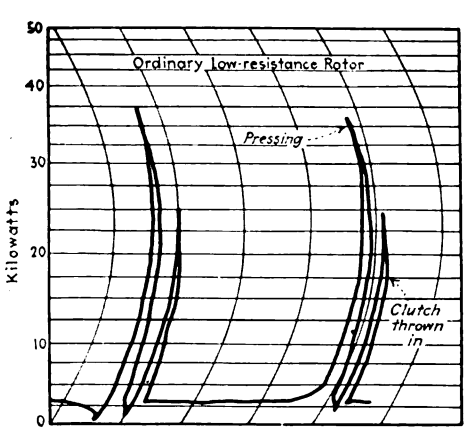
One of the most important uses of these is for elevators, cranes and hoists. In equipment of this nature the low-resistance motor is of little use. Elevator motors—and these are representative more or less of the entire class of units for hoisting work—must be able to start up a load from rest without jerks and jars; they must accelerate steadily; and they must be capable of exerting their maximum torque at the moment of starting (when the load is heaviest). Since the work of an elevator is intermittent, and consists more of starting and stopping than anything else, the limiting of the starting current is far more essential than the theoretical overall efficiency on full load. The elevator type of motor therefore has a still higher rotor resistance than that of the "half-high" torque type used for driving presses.

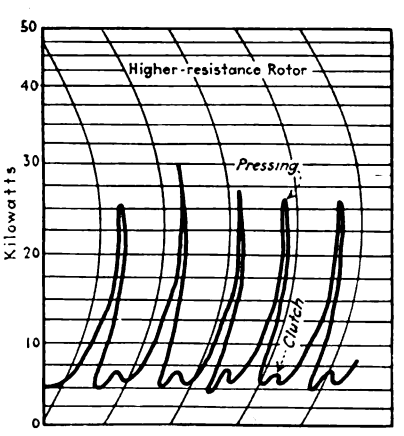
An important point to be noted is that these special types of motors are not interchangeable as regards the work they will do. Just as the low resistance of the rotor of the ordinary motor renders it useless for elevator work, so the high resistance of the elevator type would cause excessive heating if run continuously on full load even for an hour or two. The selection of the right kind of motor, therefore, to "fit the job" involves a considerable amount of investigation and research.

New York, N. Y. V. D. GREEN.

A motor with high rotor resistance is better for direct drive on a press.

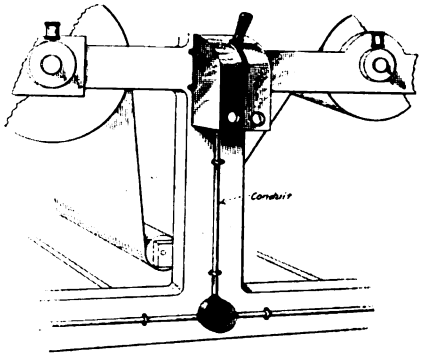
The motor in each case is driving a Stohl press making 14-gage, 7-ft. fence posts. The curve at the left is from an induction motor with the ordinary rotor. The motor which gives the curve at the right has higher resistance in its rotor.





Trouble Avoided by Use of a Special Oil-Proof Cable on Machines

THE CONTROL cable used on printing presses is especially liable to damage by the oil which is constantly present around such machines. In this connection the make-up of a small multiple-conductor cable



Printing-press control which employs oil-proof cable.

used by one of the largest printing establishments in the country for the control of large printing presses shows a very interesting development of much practical value.

The cable is run in iron pipe conduit attached to the framework of the press and also passes through junction boxes as shown in the sketch. Oil from the machinery gets into the conduit through the covers of the junction boxes, and it seems impossible to exclude it. This oil naturally causes deterioration of ordinary rubber insulation around the wires. In order to keep the oil away from the rubber insulation the special cable was tried.

Probably the main distinguishing feature of this cable is that two varnished-cambric tapes are wound in opposite directions around the assembled conductors and under the outside overall braid. In the cable there are seven No. 14 American wire gage conductors. Each of these conductors is rubber insulated and wrapped with a dry braid with distinguishing markers. Then the two varnished-cambric tapes are wound in opposite directions around the assembled conductors, and these are followed by an overall saturated braid. This gives an oil-proof cable of a diameter suitable for ¾-in. conduit. This cable has given very satisfactory service and is well adapted to the conditions encountered.

F. A. WESTBROOK.

Field Engineer.
Habirshaw Electric Cable Company, Inc., Yonkers, N. Y.

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Making Laps for Cemented Endless Leather Belts for Industrial Purposes

IN THE June, 1923, issue of the INDUSTRIAL ENGINEER, on page 309 in connection with the article on "Reclaiming Leather Belts," appeared some information supplied by The Leather Belting Exchange on "Making a Belt Scraper," one of the most important tools for belt work. Here is some additional information on making laps.

The first step is to decide on the length of the lap desired. Generally speaking, it is wise to make a new lap of the same length as the others in the belt, although when joining double belts this may be varied to suit the conditions. One lap should not be made over another lap, and it may be necessary to make a lap longer or shorter to avoid this.

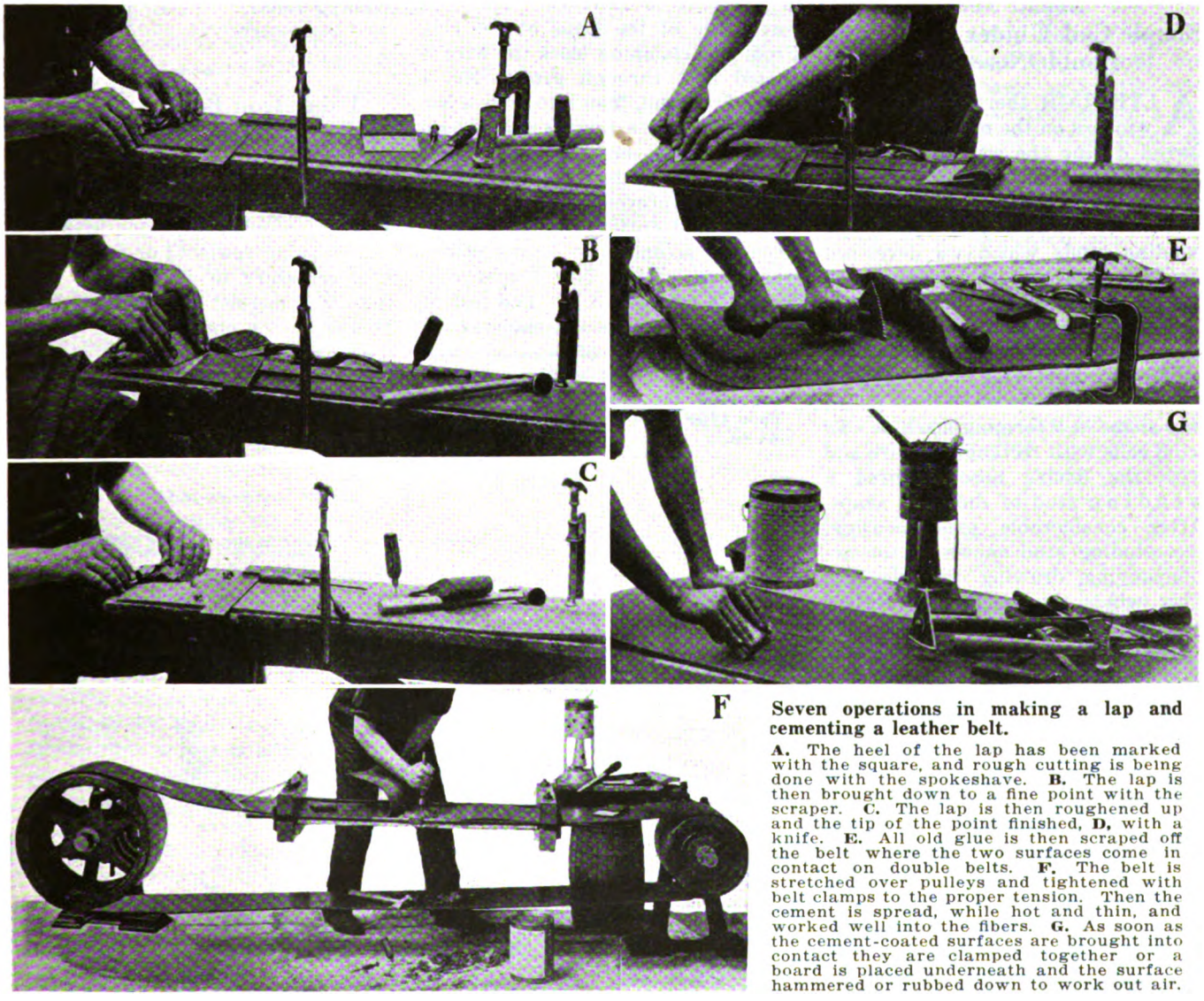
The things to be remembered are that the line of the point and the line of the heel of the beveled edge must be exactly square with the edge of the belt, and that the bevel from heel to point must be uniform and regular, and without "humps," especially back of the point, to prevent the proper adhesion of the cement at every point of contact.

Clamp the belt to the table, so that both hands are free for the use of tools, as is shown in several of the accompanying illustrations. Measure the lap desired, and mark across the belt a line drawn with the use of the square, as representing the end or heel of the lap, and proceed with the spokeshave to cut away the material, from this line down to the end of the belt, the latter becoming the point of the lap. This should be "roughed off" with the spokeshave, and then scraped down to the point with the scraper, and trimmed with a knife, as in D.

A small steel plane also can be used to advantage in connection with the spokeshave. Any man handy with tools can soon learn to make a good lap quickly. The following important points worth noting in connection with the illustrations are:

(*a*) The points of the laps always must be exactly square with the edge of the belt. Guesswork will not do here. (*b*) The lap must be gradually tapered from heel to point. Avoid a hump back of the point. (*c*) Take care to remove all the old glue, and to present a clean, fresh surface to the cement. (*d*) See that the glue is hot, and not too heavy; spread thin, working it carefully into the fibers of the leather. (*e*) Bring the two glued surfaces together, taking care that they do not slip on each other. Rub the joint with a scraper handle to supply a little pressure or place the joint between two small boards and apply pressure with the bench clamps. (*f*) Permit the glue to "set" for an hour, before putting the belt on the pulley.

LOUIS W. ARNY.
Secretary
The Leather Belting Exchange,
Philadelphia, Pa.

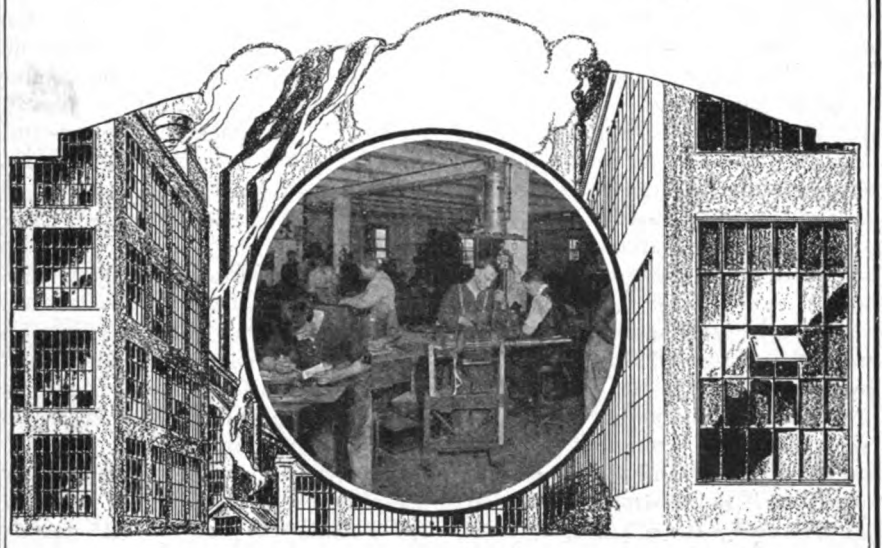


Seven operations in making a lap and cementing a leather belt.

A. The heel of the lap has been marked with the square, and rough cutting is being done with the spokeshave. **B.** The lap is then brought down to a fine point with the scraper. **C.** The lap is then roughened up and the tip of the point finished, **D,** with a knife. **E.** All old glue is then scraped off the belt where the two surfaces come in contact on double belts. **F.** The belt is stretched over pulleys and tightened with belt clamps to the proper tension. Then the cement is spread, while hot and thin, and worked well into the fibers. **G.** As soon as the cement-coated surfaces are brought into contact they are clamped together or a board is placed underneath and the surface hammered or rubbed down to work out air.

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In the Repair Shop



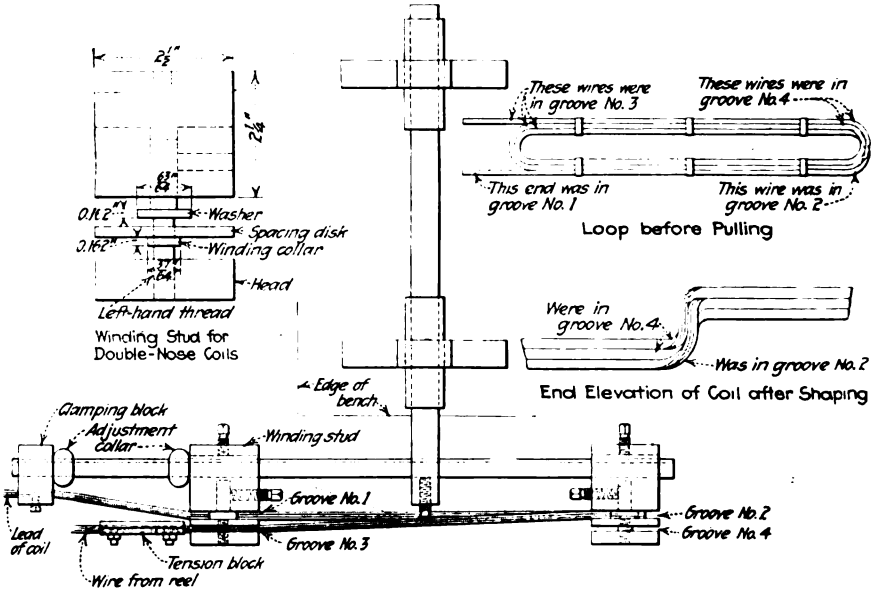
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Repair Shop Simple Coil Winder for Making Double-Nose Coils

ALTHOUGH there are good coil winders on the market, we were forced during the war to make our own winder. This winder may be interesting to other repair shops on account of its simplicity and of the winding studs which we developed for taking care of the double-nosed coils of rectangular wire. This machine at first was made with a straight winding stud for winding coils with round wire in the form of a loop. The coils were then pulled into shape in a forming machine. To wind coils with rectangular wire and with the double nose required a winding stud of different shape. After considerable experimenting, the winding stud shown in the accompanying drawing was devised. This winds the coils in a perfect manner.

The winder consists of a bearing which is mounted on the bench and which holds the main shaft. Passing through this shaft is the winding bar which carries the two winding studs. This bar is held in place on the shaft by means of a set screw which enters the outside end of the shaft. The winding studs are fastened at the proper distance from the shaft by means of their respective set screws at the back of the cross-bar. On one end of this bar is a clamping-block in which the first end of the wire is fastened. This end forms one of the loops of the coil. From this clamping-block the wire is passed first through groove No. 1 in the first stud, then into groove No. 2. One complete turn is wound into these grooves, holding the tension block as close to the winding block as possible to prevent the wire from turning and cutting the insulation. Then the second turn of the coil is started in groove No. 3 and continued in groove No. 4. The rest of the turns are then completed in grooves 3 and 4. The loop is formed so that the wires fit into each other, as shown in the upper right-hand side of the drawing, and when pulled, the coil will appear as shown in the right hand side of the drawing.

A coil winder with a special winding stud for making the double-nose type of coil with rectangular wires.



The head of the winding stud is clamped with a left-hand screw with three full threads. To remove the coil after it is wound, unscrew the heads from both studs and pull off the coil with the spacing disc and winding-collar. These two are made in one piece so that they are more easily handled while winding coils.

A special winding stud or block must be made for each different kind of coil. The particular block shown in the illustration has dimensions for a coil of three turns of three wires, each wire being 0.039 in. by 0.170 in. and insulated with a double cotton covering. This is the type of coil used in the Westinghouse 10-hp., type S K direct-current motor. For other sizes of wire and for other numbers of turns the dimensions may be different for the washer and the winding collar.

E. T. WALK.
Chief Electrician,
Mineral Point Zinc Company,
Depue, Ill.

Using Iron Band As Sling Facilitates Handling Armatures in Repair Shop

IN A REPAIR shop in which a large number of armatures are always being rewound or overhauled it is necessary to devise some easy and quick method of handling them. This condition obtains in our repair shop, and we have found that a wide sheet-iron band equipped with two eyes large enough to fit the crane hook is often to be preferred to rope

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rigging when moving heavy armatures around. As shown in the accompanying illustration, one of the eyes can easily be fastened with bolts and thus made detachable so that the band can be placed on the



The eye at one end is fastened with bolts so as to make it detachable for greater ease in handling.

floor and the armature rolled onto it. This type of band is also useful in removing armatures from small haulage locomotives where the field of the motor is in two parts. It is a simple matter to remove the eye from one end and slip the band around the armature, while it is very inconvenient to handle such an armature with a rope sling.

Comerio Falls, Bayamon, Porto Rico. FREDERICK KRUG.

Importance of Knowing Direction D. C. Motors Rotate Before Overhauling

THE direction in which the brushes are set on a commutator may be no indication of the direction of rotation of the armature because brushes are operated stubbing on one machine and trailing on another. Therefore, when a machine is sent to the repair shop to be overhauled, the direction in which the armature turned "on the job" should be known to the overhauler; otherwise the machine may be released with the shunt and compound windings connected for the wrong direction of rotation of the armature. When the operators find that the rotation is wrong for the work, the chances are that reversal will be effected by reversing the connections of only the shunt winding.

In one instance a 50-hp. motor used on a concrete mixer was sent in to be repaired and overhauled. It was in no condition to be operated, so that the direction of rotation for existing connections could not be determined by trial, and in this particular case a test might have given no helpful indication because the motor as received was wrongly connected. In any event the motor was repaired and overhauled and its series and shunt windings properly connected for clockwise rotation with trailing brushholders. When it was connected to the concrete mixer, the latter was driven in the wrong direction; without any hesitation the operator reversed the direction by reversing the shunt winding, thereby causing the two windings to oppose each other. As the series field was relatively weak, the motor operated with no signs of trouble other than sparking brushes. This did not alarm the operator because it was a condition to which he was accustomed. Later, however, he called for help because the motor could not be started. A troubleman found that failure to start was due to an open circuit in the shunt field circuit and on fixing this the motor started, but with sparking that suggested other trouble. Disconnecting the motor from its mechanical load, the troubleman again interrupted the shunt field circuit and moved the starting box handle around until the motor started on the series winding alone and rotated in the opposite direction. On reconnecting the shunt circuit and reversing the series circuit, the armature started more promptly than before and absolutely without sparking—a condition with which the operator was not familiar.

Brooklyn, N. Y. J. A. HORTON.

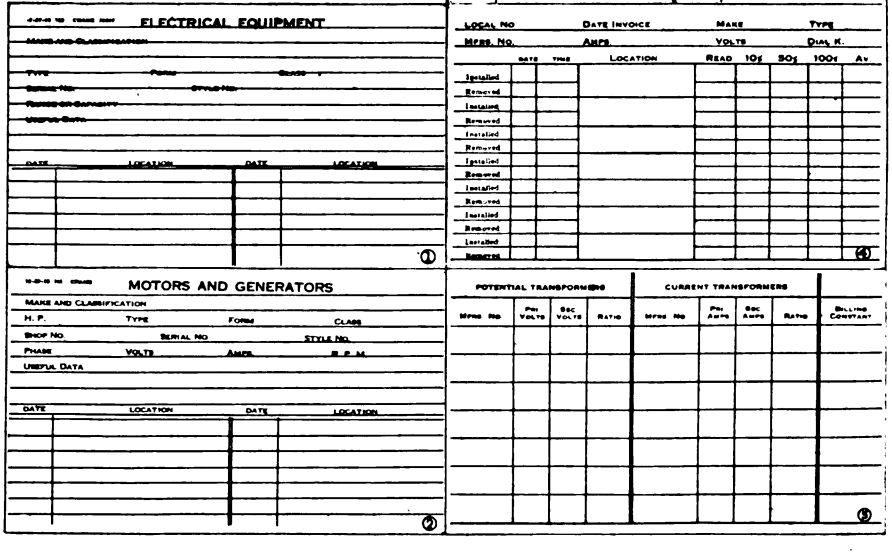
Cards Give Complete Record of Electrical Equipment

THE four card forms shown in the accompanying illustration have been of much value in systematizing the records of the electrical equipment at the Lowell Mine of the Calumet and Arizona Mining Company. These cards are of uniform size, measuring 3 in. by 5 in., and are of different colors which helps in keeping them in their proper place in the files. On the cards devoted to motors and generators there is a space for the shop number. These are serial numbers which are assigned by the electrical department and stamped on the frames of the machines. Our system of numbering makes it easy to locate the card for any motor or generator, as all of the 2-hp. motors are numbered from 200 to 299, the 3-hp. motors from 300 to 399, and so on. When there are more than 100 machines of any one size, a letter is added after the number, as 200-A, 300-A, etc. The cards are then filed according to the serial numbers. W. R. GIBSON.

Chief Electrician,
Calumet & Arizona Mining Co.,
Warren, Ariz.

Record cards like these give almost any information desired about equipment in use.

Card 1 is used for starting equipment, controllers, instruments, and so on. Card 4 is used for meters and the reverse side (not shown) furnishes a similar record for potential and current transformers.



Plans to Be Followed When Dipping and Baking Rewound Armatures

WHEN AN armature requires rewinding the general procedure is the same as for the overhauling, as was explained in a previous item in this department entitled, "Simple Suggestions to Be Followed When Dipping and Baking Armatures," which began on page 165 of the March issue.

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The first step, if rewinding is necessary, is to strip off the coils, clean commutator and test for short circuits or grounds and clean the iron. Straighten bent punchings and file off any rough surface. Wind the coils on the core, making sure that they wind snugly into the slot, using such winding cells and filling pieces as are necessary to make them tight. Wind the top part of the coils high enough in the slot for the core bands to exert a pressure on the coils when down on the core. Place leads down in an even manner so there will be no crosses in the leads. Use such insulating material as is necessary at points where there may be danger. After putting the top leads down plug the commutator and solder.

After soldering place the armature in oven for eight or ten hours for heating before banding. If the coils are high and it is thought that it will be difficult to get them down and also have tight bands run on temporary bands. Use material enough under bands to insure that the wire will not damage the winding. Place the bands so that there is no place for the varnish to pocket during dripping and baking.

If no temporary bands are needed, the permanent bands can be placed on the core, and if the armature is baked in a vertical position, the hood and end band that are up during baking can be applied if desired.

Dip and bake the armature according to the method previously outlined. After dipping and baking, turn the commutator and neck and put on the hood, insulation and permanent bands, treating the armature as recommended for overhauled armatures. Finish the completed armature in the same manner as described in the previous article.

The dipping tank should be made of sheet metal (preferably steel) of a thickness sufficient to retain the dipping compound without buckling. It should be made water-tight by welding the edges. Some tanks have been equipped with covers that are released in case of fire by the melting of a fusible wire, thus releasing a latch and dropping the cover automatically, which quickly smothers the flame. When large tanks are used with heavy covers it is somewhat more convenient to make the cover removable altogether. With this type of tank it is advisable to provide a cistern outside of the building, connected to the tank by a pipe line provided with a valve that can be readily opened, in case of fire, thus emptying the dipping compound into the cistern. In connection with the dipping tank it is necessary to provide a suitable rack on which to drain armatures after the dipping process. This can take the form of a rack placed over the tank or built at the side of the tank with a suitable drain connected.

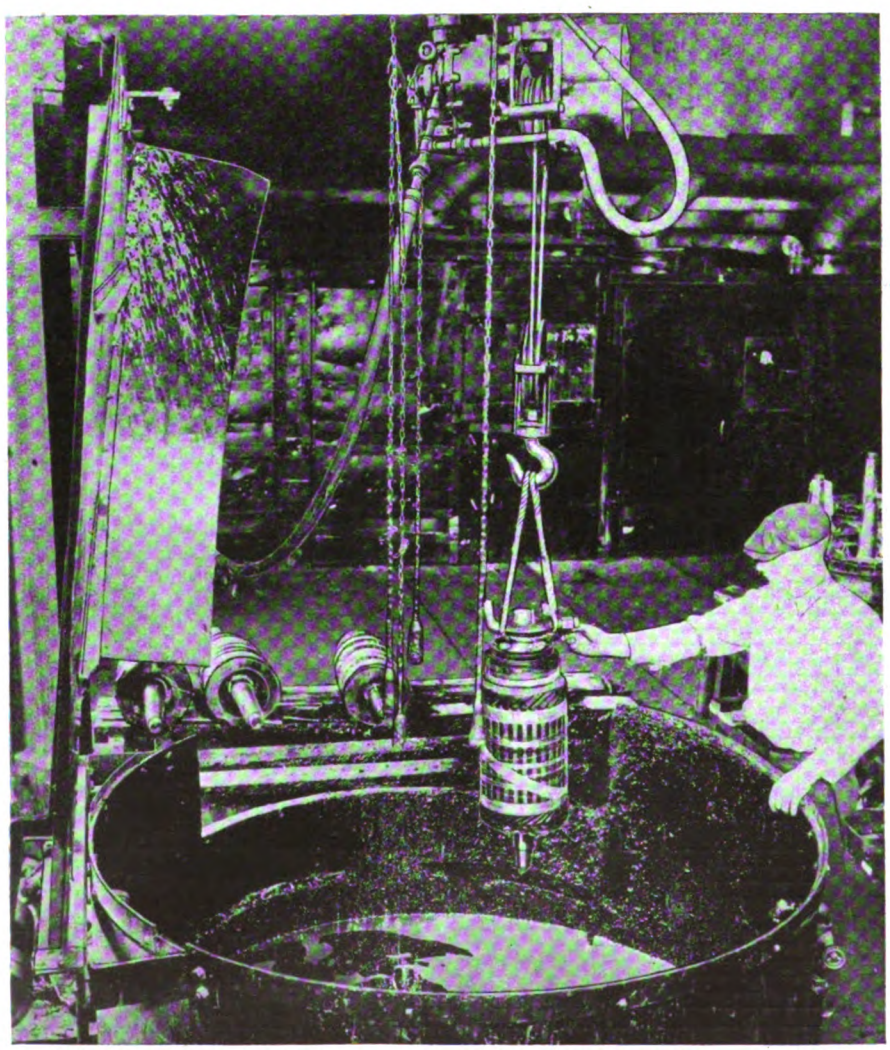
Although the practice and recommendation of the Westinghouse Electric & Manufacturing Company is to dip the armatures, a number of operating companies find it more convenient to roll their armatures in a pan or trough. Another type of tank shown in an accompanying illustration is made of sheet metal. An air hoist or a differential chain hoist above the tank is preferable to an electric hoist, since a spark from the electric-hoist motor may be the means of igniting the explosive mixture produced by the benzine vapor.

Two grades of dipping varnish commonly used in connection with the process of dipping and baking armatures are marketed—one with a china wood oil and the other with a linseed oil base. Our company has used both, as either one is suitable for this work. At present we are using a clear varnish, which has a china wood oil base, because it tends to dry out more uniformly and has a less injurious effect on built-up mica parts. The solvent for both of these varnishes is benzine.

Armature baking ovens have been made of wood lined with asbestos, sheet iron, cement or brick, and heated by either steam, hot-air furnaces or electricity. Formerly it was the practice to bake armatures at 257 deg. Fahr., from 24 to 48 hours, depending on the size. Better results are obtained from a lower baking temperature and longer baking time as the danger of taking the life out of the insulation is removed and the varnish bakes more evenly.

JOHN S. DEAN.
Motor Engineering Department,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

Dipping may be done with the armature in either a horizontal or a vertical position.



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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

An Accident Points Out That Repairs and Doing Without a Magnet for Two Months Cost More Than a New One

THE OLD ADAGE, "We never miss the water 'till the well runs dry," may be truly applied to many concerns which use material-handling equipment in their every-day activities. Here, altogether too often, the benefits resulting from this use are taken as a matter of course and the user never really considers what the equipment is doing until some mishap occurs. It is then, when the substitute equipment must be obtained that the real worth of the installation is emphasized. This, for example, was the case at the Cleveland (Ohio) plant of the Ferro Machine and Foundry Company where approximately a carload of iron is melted each day. This means the handling and rehandling of many tons of material.

For a number of years a locomotive crane with a magnet has done the unloading and other miscellaneous material-handling work around the yard. Recently the magnet, which was of an old design no longer made, gave out completely. When the question of repair arose the manufacturer of the magnet advised the purchase of a new standard magnet of modern design. At first rewinding of the coil and rebuilding the magnet was considered. A careful estimate indicated that these repairs would cost at least $1,000 and require approximately two months to complete because a new pattern would have to be made and a manganese-steel casting made and ground to size. After this the coil would have to be wound. Before deciding to rebuild the magnet the yard boss was called in to help find the cost of doing without the magnet until it could be rebuilt. He estimated that to do the magnet's work by hand would cost at least $20 a day, or for the approximately fifty working days in the two months, about another $1,000.

In this way, rebuilding the old magnet would cost about $2,000 and it would still be an old magnet without any guarantee as to its useful life, its capacity, or its effectiveness in the work. On the other hand, a new magnet would cost less than $1,500 and be covered by an absolute guarantee for one year and in addition be of modern design with greater lifting capacity and a useful life expectation of from fifteen to twenty years. With these figures in hand, it was decided at once to purchase a new magnet and effect an economy of $500 as well as eliminate a good deal of trouble and a lack of assurance that the rebuilt magnet would stand up in service for a satisfactory length of time.



To do by manual labor the work which this locomotive crane and magnet do, would cost about $20 per day.

After a number of years' service the magnet formerly installed gave out. Estimates showed that it would require about $1,000 to rebuild the magnet and another $1,000 for labor to do its work manually for the two months that would be required for the repairs. A new magnet would cost only approximately $1,500, so $500 was thus saved by the purchase of this Ohio magnet (the Ohio Electric & Controller Company, Cleveland, Ohio) and two months of trouble were avoided.

Reclaiming Coal By Loading Trucks Mechanically Instead of by Hand

THE RECLAMATION of coal from yard storage, when this is done manually, usually requires the entire time of two or three men. However, if mechanical means of loading and carrying are utilized, the same amount of work can usually be done in a much shorter time. At the industrial plant shown in the accompanying illustration, a Link-Belt portable belt conveyor (Link-Belt Company, Chicago, Ill.), is shown loading a truck. This conveyor has a capacity of 45 cu. ft. of coal a minute, which will load a motor truck in a few minutes. The big saving here, in addition to the fact that the two men who load the portable belt conveyor can do their work in much less time, is in the decrease in waiting time of the truck, as probably it would take a half hour or more to load this truck by hand. A similar time-saving advantage is gained when conveyors are used to load electric industrial trucks fitted with dump bodies, or to pile coal.

In addition to handling coal, any other loose material such as sand, stone, gravel, fertilizer, foundry refuse, debris, and similar material which is ordinarily loaded by hand shovelers, may be moved by this type of conveyor much more economically and easily and in less time. Other types of this machine may be

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A motor truck can be loaded with coal in a few minutes with this portable belt conveyor.

One of the big items of economical operation of motor trucks is to decrease the loading and unloading time to a minimum. Here the truck is loaded in a few minutes by this portable belt loader, where it would require possibly a half hour or more for two men to load it with shovels.

obtained with longer belts for higher piling or for transferring longer distances. Frequently two or more of these conveyors are placed in series—one feeding the next—and so used to carry material some distance either in piling or reclaiming. This 18-in. conveyor belt is operated at a speed of 250 ft. per min. by a 2-hp. motor mounted in the base.

Cutting Costs on Moving and Piling Material With a Tiering Machine

MATERIAL HANDLING consists usually of a group of operations such as picking up, loading, carrying, unloading or piling and returning for a new load. It is almost impossible to eliminate any of these operations but savings can be made by shortening the time of doing any of them or by increasing the load handled with the same or less effort. In the studying of any material-handling problem it always pays to investigate the operations which require more than the ordinary effort, especially those which require extra men.

One of the most conspicuous examples of this is in piling, as carrying and unloading of most articles might be performed by the trucker. When piling, however, especially if the object is heavy and must be raised to some height, the operation may require several extra men. In such cases savings may be made in various ways, such as by the use of conveyors, elevators, piling machines or other methods of doing the work. Usually these not only decrease the cost per unit but also increase the quantity moved in the same time.

At the Appalachian Corporation at New Orleans, La., for example, heavy bags of cottonseed oil meal have to be hauled about 180 ft. and piled to the ceiling, as shown at the left in the accompanying illustration. With the four-wheeled trucks shown, six bags were hauled at a trip and six men were required to pile them. If the pile was higher it would take two more men for the next tier. The cost here was 58 cents per ton.

When a Lakewood tier-lift electric truck (The Lakewood Engineering Company, Cleveland, Ohio) was used only three men were required—one on the truck and two on the pile—a reduction of half the force

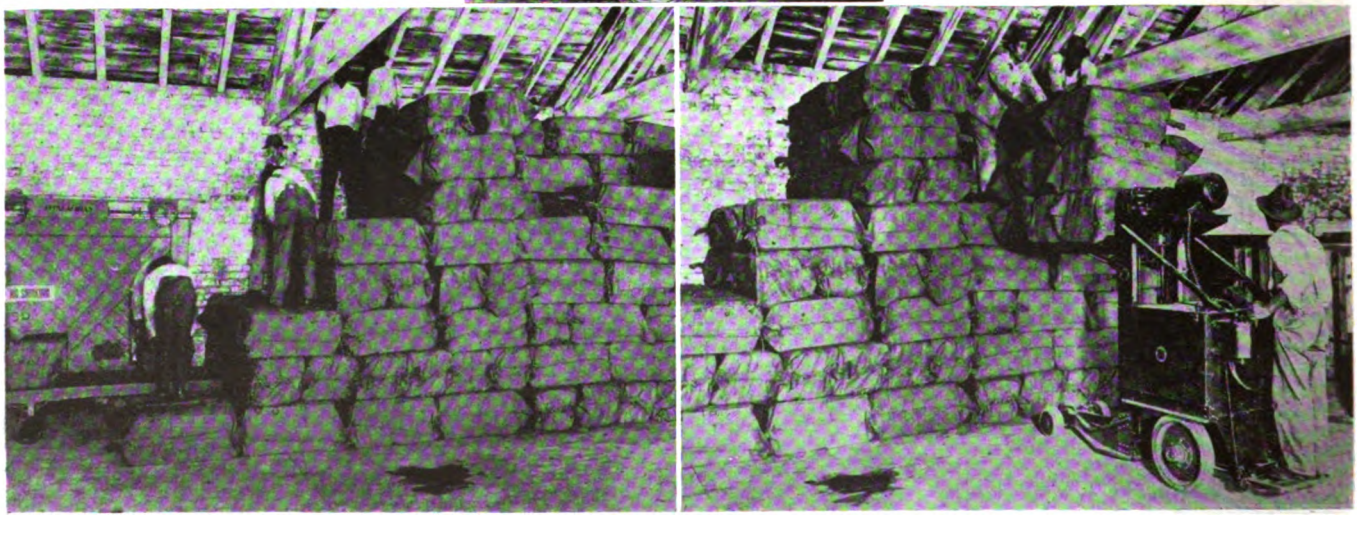
In addition, the tier-lift truck will go into the car to get its load, as shown in the smaller illustration. The length of the haul remained the same, 180 ft., after the tier-lift truck was installed as when hand trucks were used. The cost of handling with the new equipment was only 15 cents per ton. The cost of the electric energy was about 40 cents per day. In addition to this reduction of 74 per cent in the cost of handling, about 88 per cent more cottonseed oil meal was handled by the three men in a day then was possible before.

These savings were made possible by larger loads per trip, higher speed per trip both when loaded and empty, and a saving in the time and number of men required for piling. An analysis of almost any material-handling job indicates savings which may be made if only the proper equipment is applied to it. All that is required is a knowledge of what the equipment will do and what is necessary to be done.



This tier-lift truck not only reduced the cost of handling and piling these bags 74 per cent but also increased the output 88 per cent with half the force.

The tier-lift truck is driven and the load raised and lowered by electric motors which are supplied with power by storage batteries carried in the truck. Here the amount of the load was increased 50 per cent and the working force was decreased 50 per cent, with the result that 88 per cent more material was handled in a day at a cost of 15 cents per ton, compared with a previous cost of 58 cents per ton. In addition, this truck can be used as advantageously for taking material from the pile as for piling it.



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Directions for Making Motor Tests

(Continued from page 334)

is used to supply the corresponding current coil of the wattmeter, as shown in Figs. 4 and 5. In other words the current coil and potential coil must be in the same phase. In addition the currents in the current coil and in the potential coil must be in proper relative direction to insure correct operation of the meter. Connection diagrams are always furnished with recording wattmeters by the maker, but even if these are lost the meter may be connected correctly by following a simple rule. First make sure that the current and potential coils in one element of the meter connect to the same phase. Then reverse either the current or the potential leads for either side (or element) of the meter until a positive reading is secured from each of the two elements. In making these connections by trial it must be remembered that the power factor of the load must be 50 per cent or over in order to secure a positive reading on each of the two elements. After the correct connection is found by this method a diagram is made and followed for any other loads.

In order to make testing easier it has been the writer's method when installing compensators and motors to connect the leads from the starting compensator to the leads running to the motor by means of a brass sleeve wire connector shown in Fig. 5. The wires are held in this connector by means of four screws. In making motor tests where the drive may be shut down for five minutes the current transformer loop may be inserted after opening up two of these leads, as in Fig. 4. The third wire connector is untaped and the middle potential lead is attached by a battery clip.

After the connections are made it is good policy to tape up the exposed wire ends and connectors. Before starting the motor the current transformers should each be short-circuited on the secondary side, to prevent the heavy starting current from throwing the meter pointers off scale. Some current transformers have short-circuiting switches which may be used for this purpose. Where there is no such switch a piece of flexible wire may be wrapped around the binding posts. After the motor has started the short is removed. If, however, it is desired to measure the starting current, no short circuiting is necessary. The transformer in this case, though, must be of such a ratio that the starting current will not damage the meter.

In case it is impossible to shut down a drive long enough to insert the testing leads, a current-tap lug such as that furnished by the States Company has been used by the writer as shown in Fig. 5. One of these lugs to which is attached a current-transformer lead, is clamped to the bare wire on either side of the wire connectors. Then the wire connector is opened and the current flows around the opening through the current transformer. On voltages below 550 there is little danger if the electrician is careful and wears rubber gloves and stands on a dry board.

A Case Where a Motor Test Was Valuable

An illustration of using the motor test to detect the cause of an overload on a motor is afforded by the accompanying motor-test records, Nos. 673 and 674, shown in Fig. 2 and the corresponding meter charts in Fig. 6. In test No. 673 the no-load input to the motor indicated 26.8 hp. when there was no water flowing through the pump. The average load when pumping with clear water or a mixture of water and cinders was 165.2 hp. From the data you will note that the driving motor is rated at 75 hp. which was ample for driving the pump at full load under normal conditions. After the motor had been running abnormally hot, test No. 673 was made to determine the nature and amount of the overloading. As the load on the pump was not affected by the quantity of cinders handled with the water, it was evident that the excessive load was caused by some mechanical defect in the drive. The covering over the pump was dismantled and in dismantling the pump it was found that one of the flanged couplings next to the pump had become loose on the shaft, thus allowing the unbalanced water pressure against the impeller to force the impeller against the pump casing. The thrust bearing for this pump was located on the side opposite the loose coupling. After a new coupling had been put on the pump shaft the drive was assembled and test No. 674 was then made which showed an input to the motor of 70.5 hp., on the average.

A somewhat similar example was shown in tests on a double-reduction-geared coal-mine hoist. The motor, which was of the slip-ring type, had been giving trouble and it had burned off several jumpers on the rotor bars. When the first test was made it was found that the load of one empty cage going up was higher than that of the other empty cage when going up. As the hoist was of balanced construction this condition, of course, should not have existed. A thorough inspection of the drive was then made and it was found that the brake band which had recently been relined did not have sufficient clearance when released. The brake was of the contracting-band type and the tendency was to grab more firmly when running in one direction than when running in the other. After the release mechanism had been changed to give a greater clearance to the brake band the load was reduced almost one-half for both starting and running.

Distribution and Chord Factors

(Continued from page 355)

are wound full pitch or whose sides lie in slots 1 and 7. It will be noted from the arrowheads on the coil sides showing the direction of the current at a given instant, that the center line of one pole lies between slots 6 and 7, and that the arrowheads for both tops and bottoms of slots are in exact symmetry on either side of this center line. Comparing Fig. 11, which shows a similar winding except that the coils are chorded and wound in slots 1 and 5, it will be seen that the center line of a pole now lies between slots 5 and 6, and another between slots 11 and 12. The arrows in slots 5 and 6 and 11 and 12 are in opposite directions, and hence the effect of the winding in these slots cancels out. If the shape of the magnetic field form in the two cases of Fig. 9 and Fig. 11 be plotted out by the well known "stair step" method,* it will be found that the shape of the resulting field from the winding in Fig. 11 is flatter on top and not quite so nearly a sine curve shape as would be the field resulting from the winding shown in Fig. 9. From this comparison can be drawn directly the fact that the *chord factor*, which depends on the throw of the coil, is different for the windings shown in

*See Dudley's "Connecting Induction Motors," published by McGraw-Hill Book Company.

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Figs. 9 and 11, but the *distribution factors* are the same. On the other hand, comparing Figs. 9 and 10, the *chord factors* of these two windings are the same because the coils have the same throw but the *distribution factors* are different, as explained in connection with Fig. 6.

From the foregoing discussion it may be seen that the *distribution factor* is a measure of how efficiently the turns in the winding are used. In other words, a direct-current field coil, as illustrated in Fig. 1, makes 100 per cent use of the turns, whereas a single-phase winding as shown in diagram *B* of Fig. 3 only uses them 63.6 per cent efficiently. Again the effectiveness of the turns is a measure of the possible output, either in the form of electrical energy as in a generator, or mechanical energy as in a motor, from a given weight of copper, so that all things being considered, that connection should be used which will give the highest possible *distribution factor*.

Material Moves With Production

(Continued from page 347)

rolled by hand over onto the other flange which is then straightened by the second bulldozer on the other side of the machine, thus allowing two poles to be in process at the same time.

The poles, resting on rollers, are then pushed off the straightening machine back across the cooling chains and sent through a brushing machine. This consists of a number of rapidly revolving steel brushes. On the first pass through the machine one side of the pole is thoroughly brushed to remove all loose scale and dirt. The second pass, whereby the other side of the pole is brushed, is made in the opposite direction and through the other side of the machine. The poles are thus returned to the cooling chains and after traveling a short distance are picked up by a floor-operated 2-ton Shepard hoist and immersed for about a minute in a long narrow tank containing paint. The paint is kept at a temperature of 140 deg. F. by means of steam coils and the temperature of the poles when they are dipped is about 200 deg. F. As a result the paint is baked on the poles, which are dry a few minutes after they are removed from the tank and placed on the discharge table.

The chemical composition, particularly the carbon content, of the metal in the beams is closely controlled with the result that very few defective poles are produced. Further, the act of expanding is sufficient to reveal all hidden defects. Imperfections are, of course, easily seen and poles which are not perfect are removed from the cooling chains and put aside before being painted.

The lacings are cut from the flanges of defective poles by means of the oxy-acetylene torch and the flanges are then used to make base extensions or splice plates for poles. On the whole there is so little waste produced in the manufacture of poles that it requires several years to accumulate a carload of scrap.

After the paint is dry the poles are carried by a 3-ton cage-operated Shepard monorail hoist to finished storage or loaded directly into cars for shipment. For ocean and also for less-than-carload shipments the poles are fastened together by special clips in bundles of three poles each. In order to facilitate the loading of cars, two outgoing tracks are available: one through the building, a comparatively short distance from the paint-drying table, and another which runs close to the wall, outside of the building. The monorail track, on which travels the hoist for dipping the poles in the paint tank, extends the length of the building and over the outdoor loading track. On this overhead track there are three monorail hoists, one floor- and two cage-operated, so that cars on the two outgoing tracks can, if desired, be loaded simultaneously from both finished storage and directly from the paint-drying table.

From the layout of the plant, shown in one of the accompanying illustrations, it will be seen that the material in process does not at any time back-track: the movement is continuously forward from the time the beams, the raw material, are unloaded from the cars, until the poles, the finished product, are placed in finished storage, or loaded on the cars for shipment.

In the process of manufacture there are twelve operations, as follows: (1) Unload beams and put in storage; (2) take beams from storage to shear; (3) shear and punch holes; (4) take beams from shear to storage; (5) take beams from storage to furnace; (6) take beams from furnace to expander; (7) expand; (8) take expanded beam, or pole, to cooling chains; (9) straighten; (10) brush; (11) dip in paint; (12) load poles in cars, or take to storage. Of these operations, expanding takes the most time and is used as the base for timing. Two minutes are allowed for this operation, although it has been done in somewhat less time, and an occasional check is made to see that this schedule is maintained. If the time required averages much more than two minutes an investigation is made to determine the cause. The operator of the expanding machine thus sets the pace for the entire plant and, inasmuch as all of the operations are so closely connected, any lagging either before or after the expanding operation is easily detected. Maximum output under present conditions is thus obtained with a minimum of supervision.

Types and Kinds of Chain Drives

(Continued from page 339)

removed occasionally, of course, more frequently in a dusty location, the case cleaned out and refilled with new oil. Improper lubrication is one of the most common forms of neglect of chain drives.

Acording to one manufacturer of silent chains the best method of lubricating a chain drive is to enclose it in a sheet metal casing and permit the chain to operate in a bath of oil. Such a casing to retain oil must have welded joints or be of pressed steel and requires some method of enclosing the openings around the shafts, such as by felt or leather washers. These casings are usually made in upper and lower halves and should be reinforced around the edges with angle-iron and the upper half allowed to extend down into the lower half about 2 in. Such an installation will lengthen the life of a chain drive from 50 to 100 per cent and is advisable on most chain-drive installations and necessary on installations where the speed is high. There is, however, a large number of installations where such a method of lubrication is not absolutely necessary and in these cases lubrication should be provided by oiling not less than every other day. Nothing but a light lubricating oil should be used and of the best quality obtainable. Cheap oils and heavy greases tend to form gum on the links and prevent lubricant from reaching the joints. Oil should be applied to the inside of

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the chain while running so that the centrifugal force will tend to throw the oil out to the pins. As soon as oil begins to appear on the back of the chain it is an indication that sufficient lubrication is on the chain for the time being.

Another manufacturer recommends the following method of lubricating roller chain drives. Clean the chain thoroughly in a bath of gasoline or kerosene and then completely immerse it in hot, liquid graphite grease, and leave it in until it has become as hot as the grease. Otherwise, the grease merely chills on the surface of the chain and does not penetrate. For the best results, it is desirable to heat the chain itself before putting into the graphite bath.

After removing the chain from the bath, place it on a level surface and push the links together so as to take up all the stress, thus permitting the lubricant to become settled in the bearing. When the chain is cold, wipe it off well on the outside before placing in service to prevent the excess lubricant gathering dust and grit. The use of stick graphite is not recommended because it merely places the graphite on the outside of the chain and so silences it slightly without removing the cause of the noise or working into and lubricating the wearing parts. It also gathers dust which works into the chain and causes excessive wear.

The frequency of lubrication depends entirely upon the purpose for which the drive is used. This method of lubricating a chain is recommended as secondary to operation when immersed in oil. Experience has shown that a chain properly cared for and run in oil has lasted six or seven times as long as a chain operated under similar duty on an exposed drive.

Another article in a later issue will take up other points on the selection of chains, their application and their use and abuse in service.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assisting in furnishing information and photographs for this and the article which is to follow on this subject: American High Speed Chain Co., Indianapolis, Ind.; The Baldwin Chain & Manufacturing Co., Worcester, Mass.; Cullman Wheel Company, Chicago, Ill.; Diamond Chain & Manufacturing Co., Indianapolis, Ind.; Duckworth Chain & Manufacturing Co., Springfield, Mass.; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; The Whitney Manufacturing Co., Hartford, Conn.

Practical Books
For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

E M F Electrical Year Book—Edited by F. H. Bernhard, second edition, published by Electrical Trade Publishing Company, Chicago, Ill., 1,230 pages, illustrated. Price, $10.

This Year Book is a combined dictionary, encyclopedia and trade directory covering the electrical industry, with all topics arranged alphabetically. Practically every electrical and closely allied product is listed, defined and followed by a complete list of its manufacturers; every trade name used by the industry is also listed and information given about the product it relates to, together with the name of the manufacturer. In addition, every manufacturer is listed separately by company name and information is given about the office, product made and location of district offices. There are also thousands of additional entries covering the definitions of all electrical words and terms, historical and statistical information about electrical applications and activities, biographical sketches of prominent scientists and engineers, and information about electrical associations, schools, colleges, patents, exports, and many other allied subjects. All of this information is likewise compiled alphabetically.

* * * *

Electric Transients—By C. E. Magnusson, A. Kahn and J. R. Tolmie. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. First edition, 190 pages. Price, $2.50.

The increasing size and complexity of electrical systems and apparatus are making necessary a closer study of transient electric phenomena, those changes which take place in a system with changes of load. Those who are interested in such phenomena will find much to interest them in this book which is based on an introductory lecture and laboratory course that has been given for some years to electrical engineering students in the University of Washington. The purpose of the book is to give a clear conception of the fundamental principles of electric transient phenomena and their application to quantitative problems. In keeping with the elementary treatment of the subject the first chapters are devoted to the definition of, and formulas for, the properties of electric, dielectric and magnetic circuits. Chapter two deals with oscillographs, describing the types which are on the market, with wiring diagrams and directions for taking oscillograms. Other chapter headings are: single energy transients, direct currents; single energy transients, alternating currents; double energy transients; electric line oscillations: surges and traveling waves; variable circuit constants; resonance; oscillograms. The text is liberally illustrated and supplemented by a large number of oscillograms of transients that occur in the various types of machines and electric circuits in common use in electrical engineering laboratories. In an appendix there are given directions on the technique of developing and printing oscillograms.

* * * *

Metals and Their Alloys—By Charles Vickers, published by Henry Carey Baird and Company, Inc., 2 West Forty-fifth Street, New York City, 800 pages. Price, $7.50.

The author, a well-known authority, has prepared a thoroughly practical book which is partly based on Wm. T. Brannt's "Metallic Alloys." It contains a description of the best American practices in dealing with metals and their alloys and takes up the chemical as well as the physical properties and many of the applications of alloys in various industries. Included in this is information on the various alloys of aluminum and the proportions to be used for different purposes as well as a chapter on die casting, die casting methods, machines and applications.

The alloys have been placed in twelve distinctive groups, according to the metal used as base, and are as follows: (1) aluminum alloys, (2) bronzes, (3) brasses, (4) nickel alloys, (5) tin alloys, (6) lead alloys, (7) amalgams, (8) alloys of the precious metals, (9) fusible alloys, (10) iron alloys, (11) magnesium alloys, (12) zinc alloys.

Those working with alloys can use this not only as a guide, but also as a reference work for there are included hundreds of tables giving the composition, properties and analysis of alloys of every description and for almost every purpose.

* * * *

Plastic and Moulded Electrical Insulation—By Emile Hemming, President, American Insulator Corporation. Published by The Chemical Catalogue Company, 19 East 24th Street, New York, N. Y. 313 pages, illustrated.

There are in existence burned clay objects estimated to be 10,000 years old and which may be taken as evidence that the manufacture of ceramic products is one of the very oldest industries. In this book, which is one of the few, if not the only treatise on the subject, the author discusses in considerable detail the properties, manufacture and method of forming plastic materials into the desired shapes. It is an interesting story and it is told in such manner that the layman will find it easy to read and understand, while the expert will come across much valuable information. The book is divided into two sections. The subjects covered in the various chapters of the first part are: ceramic products, including the raw materials and

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the method of manufacturing and coloring ceramic ware; calcareous cements and artificial stones, mortar, cement, concrete and plaster; glass, its history and manufacture, raw materials and manipulation; casein products, origin and uses; plastics in road construction, foundations, road repairs and pavements; sundry patent references, covering a number of compositions of varied character.

The second section of the book is devoted to molded insulation and comprises six chapters, as follows: history of molded insulation; raw materials; classification, hot-molded, cold-molded, ceramics, rubber compounds, and so on; molds and dies; selection of materials; properties and relative characteristics.

An especially valuable feature is the inclusion at the end of each chapter of a list of the patents issued, and the points covered, on the subjects treated therein.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

E. C. Atkins and Company, Indianapolis, Ind.—A unique piece of literature distributed by this company contains the Constitution of the United States of America, with the Amendments and Reference to the Bill of Rights. The foundations of our Republic rest on the principles outlined in the Constitution and in many quarters these are being undermined. This may be overcome to a large extent by a wider knowledge of the provisions of our Constitution. For this reason the company has gone to the expense of publishing the Constitution in handy pamphlet form free from advertising. A copy will be mailed to any individual interested.

The Surty Manufacturing Company, Inc., 4131 West Kinzie Street, Chicago, Ill.—A folder describes the Surty belt handler which is used to remove and replace belt on machines such as punch presses where it is desirable to remove the belt for safety while setting the die. With this equipment it is claimed that a belt can be removed or replaced in three seconds. The folder also describes a shifting device for the automatic shifting of cone-pulley belts.

Benjamin Electric Manufacturing Company, 847 West Jackson Boulevard, Chicago, Ill.—A small folder describing the Benjamin-Starrett dead-front standardized panel boards describes and lists the different features embodied in them. These are listed in capacities of four to thirty circuits and are furnished with tumble, push or knife switches.

The Gellman Wrench Corporation, Rock Island, Ill.—A folder describes the Gellman "Polly" quick-adjusting wrench. It is made in three sizes, 6-in., 9-in. and 12-in. with corresponding jaw openings up to $\frac{1}{8}$ in., 1 in., and $1\frac{7}{8}$ in.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio.—Literature on the new "Imperial Undercutter" gives some of the unusual features of this slotting machine, such as that it is driven through a 4 ft. flexible shaft from an electric drill and therefore may be purchased with or without the motor; it has a movable block with guide for riding in an adjacent slot; it has a micrometer screw adjustment to set the saw in the exact center of the mica; compressed-air line may be attached to blow the dust away from in front of the cutter; "V"-shaped milling cutters are used instead of square saws to give a "V"-shaped slot.

Jewell Belting Company, Hartford, Conn.—A small booklet entitled, "Useful Information Concerning Belts and Their Application," gives in condensed form a large amount of information on measuring belts, finding the velocity of the belt, how to order belting, suggestions for the care and operation of belts, determining the horsepower and other subjects.

Birdsboro Steel Foundry and Machine Company, Birdsboro, Berks County, Pa.—A booklet describes the Jackson belt lacer. This is a special hinged joint made by a machine which laces a coil of wire through each end of the belt. The coil is then flattened out, the two ends of the belt put together and joined by a pin. One feature of this booklet is a chart illustrating, numbering and listing the parts of the belt lacing machine to facilitate ordering repairs. In addition several pages are devoted to pulley and belting data.

Western Electric Company, 195 Broadway, New York City—Publication 23021 describes the "Tork Clocks" which are used for turning electric lights on and off regularly. A phantom view shows the details of construction and operation of this clock. This is made in three sizes for 6 amp. 125 volts, 15 amp. 250 volts, or 30 amp. 250 volts.

Thermalene Gas Corporation, Kankakee, Ill.—A folder describes the "Thermalene Ideal Goggles" which are of a new design so arranged that they are held away from the face and are hinged so that the lenses may be raised between cutting or welding periods when examining the work, thus making it unnecessary to remove the goggles from the face.

The Cleveland Crane & Engineering Company, Wickliffe, Ohio—A loose-leaf catalog No. 2 describes the various uses and applications of the Cleveland Electric Tramrail. This takes up illustrations and descriptions of various installations in foundries, warehouses and other plants, as well as hand and electric carriers, cranes and transfer bridges, attachments, fittings, and numerous suggestions for applications and installations. A number of pages is devoted to the practical information which would be needed for the installation as well as for laying out of equipment of this sort.

Roller-Smith Company, 233 Broadway, New York City—Bulletin 250 describes the Roller-Smith Portable Direct Current Galvanometers, types LGD and KGD for use where sensitive but very rugged devices are wanted.

Victor Balata and Textile Belting Company, 48 Murray Street, New York City—A booklet entitled, "How to Figure Belts," gives a number of rules, tables and other data for determining the correct drive for various kinds of belts. Two special features are the pages devoted to "Helpful Hints" and to the transmission card showing the information desired or needed when selecting a belt for particularly unusual service conditions. Other folders describe each of the various types and grades of stitched canvas and Balata beltings manufactured.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A small folder lists prices and describes the "Efficiency" refillable plug fuses. These are made in capacities of 6, 10, 15, 20 and 30 amp., 125 volts. These are so constructed that the refillable section for a 20 amp. fuse, for example, cannot be seated in a plug rated at 10 amp.

Allis-Chalmers Manufacturing Company, Milwaukee, Wis.—A 58-page booklet is devoted to centrifugal pumps and motor-driven centrifugal pumping units. Numerous tables and other engineering data as well as a complete description of the equipment and illustrations of a number of installations are included.

American Spiral Pipe Works, Chicago, Ill.—Catalog 22 describes and illustrates the construction and many of the applications of Taylor spiral riveted pressure pipe. Some space is devoted to special steel fittings and to engineering data on the flow of water through pipes and other useful information.

The Bryant Electric Company, Bridgeport, Conn.—A number of revised loose-leaf catalog pages have been recently issued which supersede pages previously issued. Those having catalogs can in this way keep their catalog up-to-date.

The Stanley Belting Corporation, 32-40 South Clinton Street, Chicago, Ill.—A 16-page booklet on the Stanley solid-woven cotton belting illustrates and describes the special features and particular applications to which Stanley solid-woven cotton belting is well adapted. One page is devoted to a discussion of the various types of fasteners recommended for use in connecting this belting.

Bussmann Manufacturing Company, St. Louis, Mo.—A booklet entitled, "The New Knife Blade Type Renewable Fuse," describes and illustrates construction and operating details of a knife blade type of renewable fuse.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

August, 1923

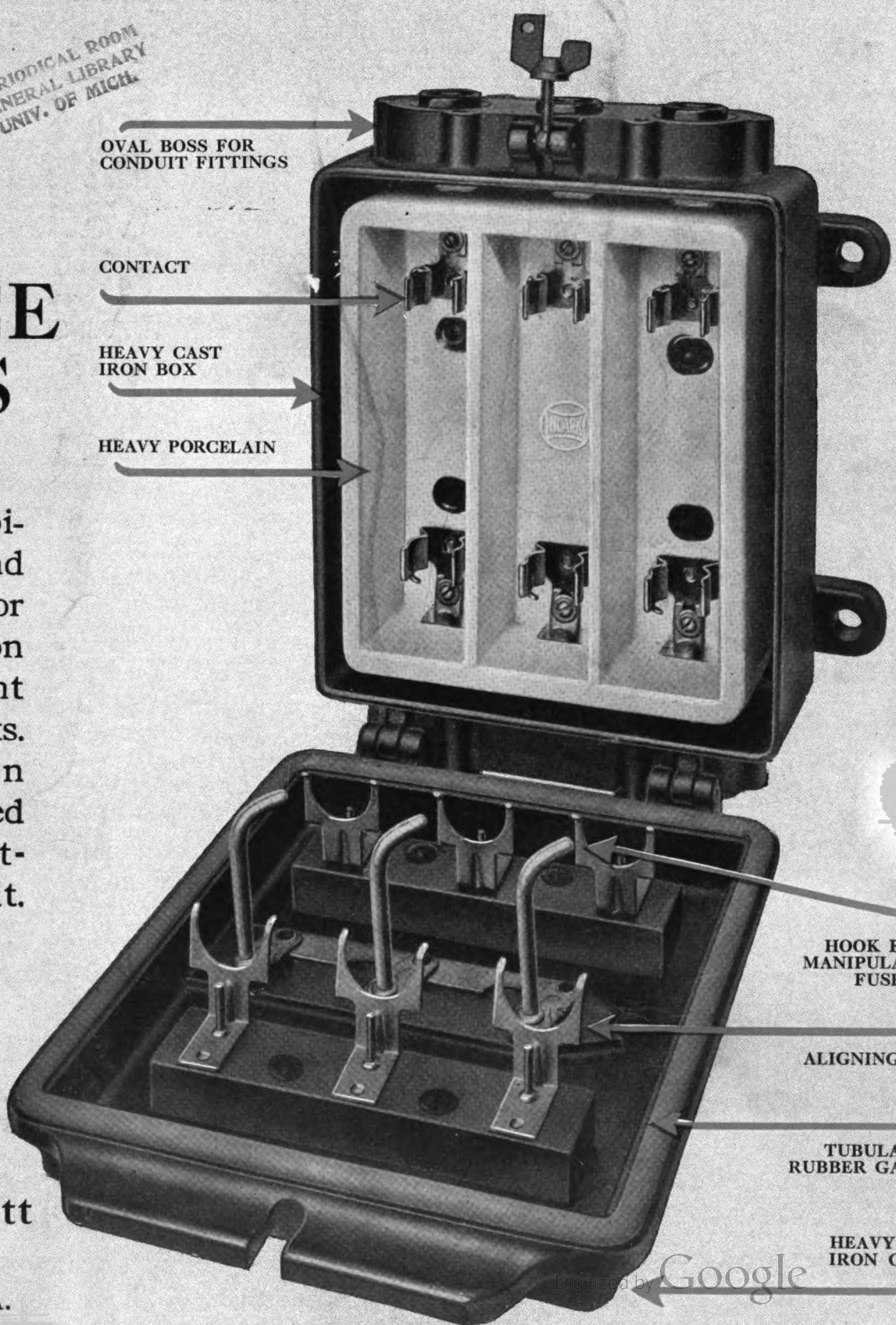
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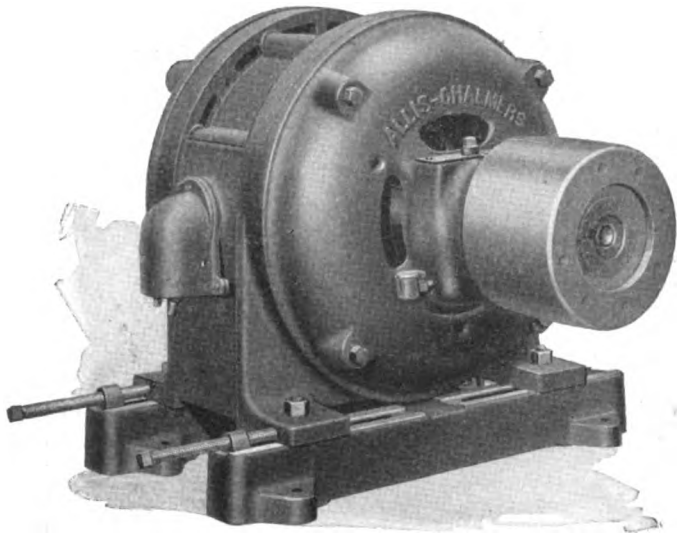
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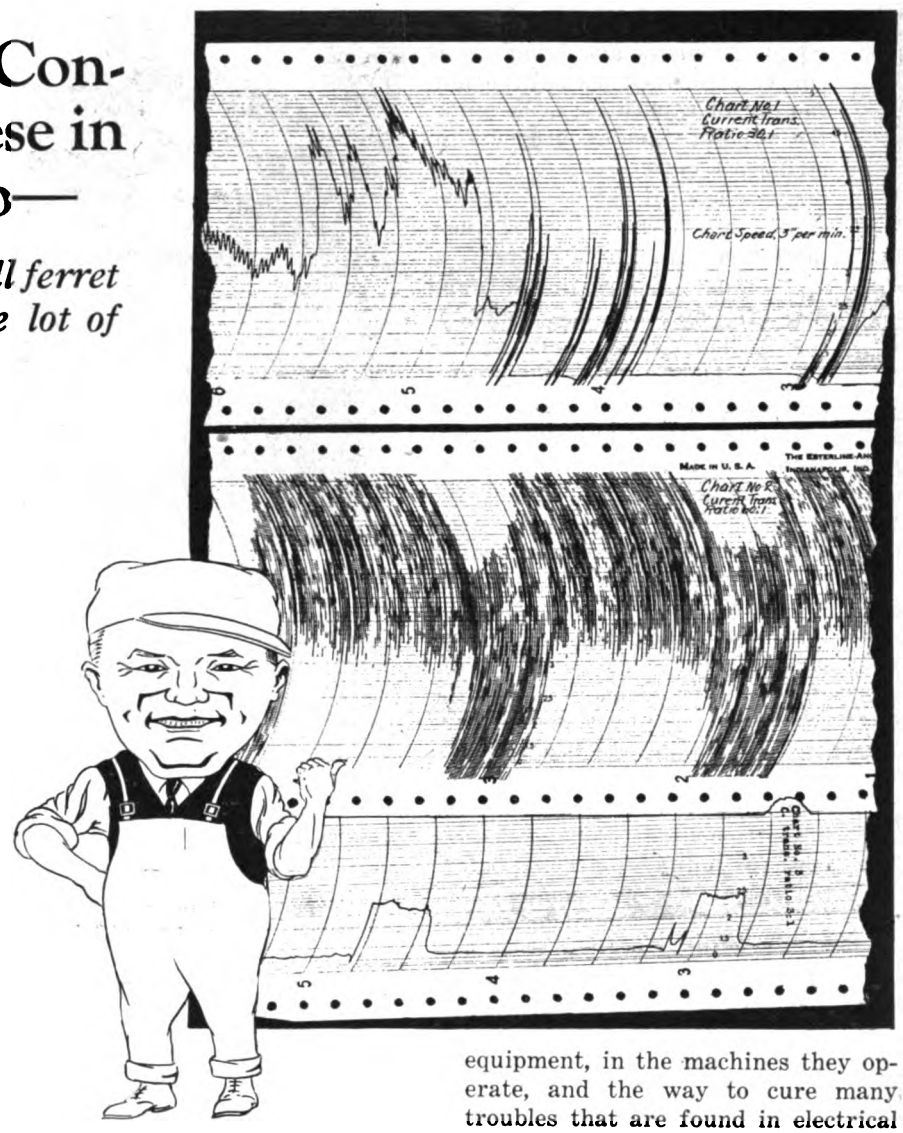
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, August, 1923 *Number 8*

You May Have Conditions Like These in Your Plant, Too—

That a thorough testing will ferret out and save you a whole lot of future worries



FELLOWS, I've just received a fine letter from C. H. Funderburg, with the Woodward Iron Company at Woodward, Ala. It carries two points that I want to pass on to you. First, the best way to cure troubles is to chase them to their source and find them before they spread. Second, Mr. Funderburg works with his head as well as his hands. His letter follows:

I was very much interested in the article on pages 331 to 334 of the July issue of INDUSTRIAL ENGINEER on testing motors. For the past few weeks I have been testing motors for a mining company by which I am employed.

The mines are well equipped with proper sizes of motors, most of which operate at 3300 volts, 25 cycles. These motors are used to operate hoists, compressors, pumps and other mine machinery. Since it would have been difficult to carry transformers for a watt-hour meter through a mine with a pitching seam we used a graphic ammeter in making the tests.

The original idea was to determine the cycle of operation of the hoist motors. There are five 700-hp. hoist motors, three 500-hp. hoist motors, two 200-hp. hoist motors and several smaller hoist motors, all of the slip-ring, induction type.

To our surprise the tests not only furnished the cycle of operation but showed defects in the driving mechanism. On one 700-hp. hoist motor the graphic chart showed a swing of the needle at regular intervals. Upon noticing this I began to look for the trouble and found that it was due to a high spot on the brake drum, which rubbed on the brake band each revolution of the drum. See chart No. 1.

One of the air compressors driven by a 700-hp. motor had a bad gear. This gear did not make any noise but I found that for every revolution of this gear there was a distinct swing of the needle. See chart No. 2. One week later this gear went to pieces but the findings from the test gave us time to have another made.

In testing a motor on one of the centrifugal pumps, the chart showed that the pump had regular intervals of pumping and churning the water. See chart No. 3. The tests on several other motors showed troubles in the driving mechanism that would not have been normally noticed.

Mr. Funderburg has illustrated exactly what we mean when we say that INDUSTRIAL ENGINEER is devoted to the maintenance and operation of electrical and associated mechanical systems. In many cases the troubles that show up in a piece of electrical equipment are located outside that equipment, in the machines they operate, and the way to cure many troubles that are found in electrical apparatus is to hunt them down to their source. Simply taking a damaged motor out of service for repairs and replacing it by another does not do the trick. Do you get the point?

The real trouble may be upstairs, downstairs, or somewhere else along the line and it is more apt to be mechanical than electrical.

Practical Pete

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A Glimpse Into the Works of

E. I. du Pont de Nemours and Company

Where a large group of dissimilar products are produced through the development and extension of related industrial processes. The eighth of a series devoted to the growth and extent of our basic American industries.

THE NAME of E. I du Pont de Nemours and Company is chiefly associated with the manufacture of explosives; although at the present time it produces in addition a large group of dissimilar products. It has been engaged in the production of these basic materials since 1802 when E. I. du Pont de Nemours, then a young man 28 years of age, came to the United States from France and established his first powder mill near Wilmington, Del.

He was helped by Thomas Jefferson, and others who saw the great advantage of having the United States independent in its supply of gunpowder. Among his earliest consignments was powder for war against the pirates of Tripoli and the company has supplied powder in all wars since. However, the company can not be considered as a military institution, for its growth has been dependent on other industrial and commercial developments. The proportion of du Pont explosives used for military purposes before the recent war was small—about 5 per cent. The remainder, except for sporting powders, was used for industrial purposes, and was indispensable to modern industry.

During the life of the company, through the use of explosives, more than 250,000 miles of railroad and more than 2,000,000 miles of highways have been built in the United States, and in one single year more than 600,000,000 tons of coal have been mined. Quarries use 60,000,000 lb. of dynamite per year. About 1,000 lb. of explosives are required to produce the material required for a mile of 16-ft. road. Coal mining uses 302,000,000 lb. of explosives, other mining demands 90,000,000 lb. and agriculture requires 20,000,000 lb. of dynamite annually.



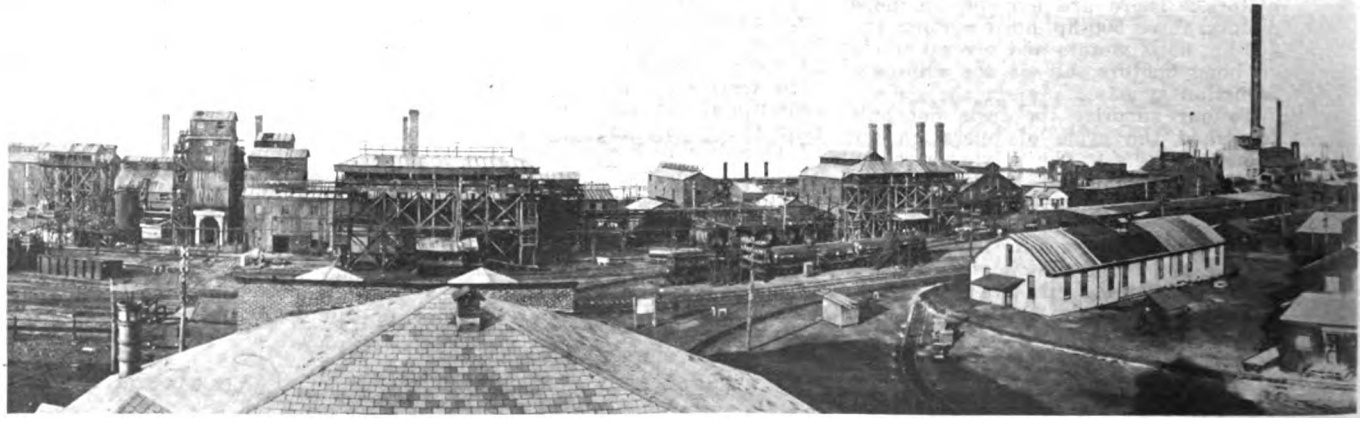


The first powder factory and office of the du Pont Company.

The oldest powder mill in the United States (upper illustration) was built by E. I. du Pont de Nemours in 1802 on the banks of the Brandywine near Wilmington, Del., to supply powder for the Government. From the beginning officers of the United States Government have worked hand in hand with the du Pont Company in the latter's laboratories, the joint efforts of all being directed toward maintaining the United States in a position of leadership in the production of the most modern and effective military powders.

The manufacture of explosives is today an important chemical industry and the ramifications of this manufacture have led the du Pont Company into related lines of industry so that it produces not only explosives, but also dyes, enamels, chemicals, paints and varnishes, pyralin (a pyroxylin product) and fabrikoid, an impervious fabric with a cloth foundation and a pyroxylin surface.

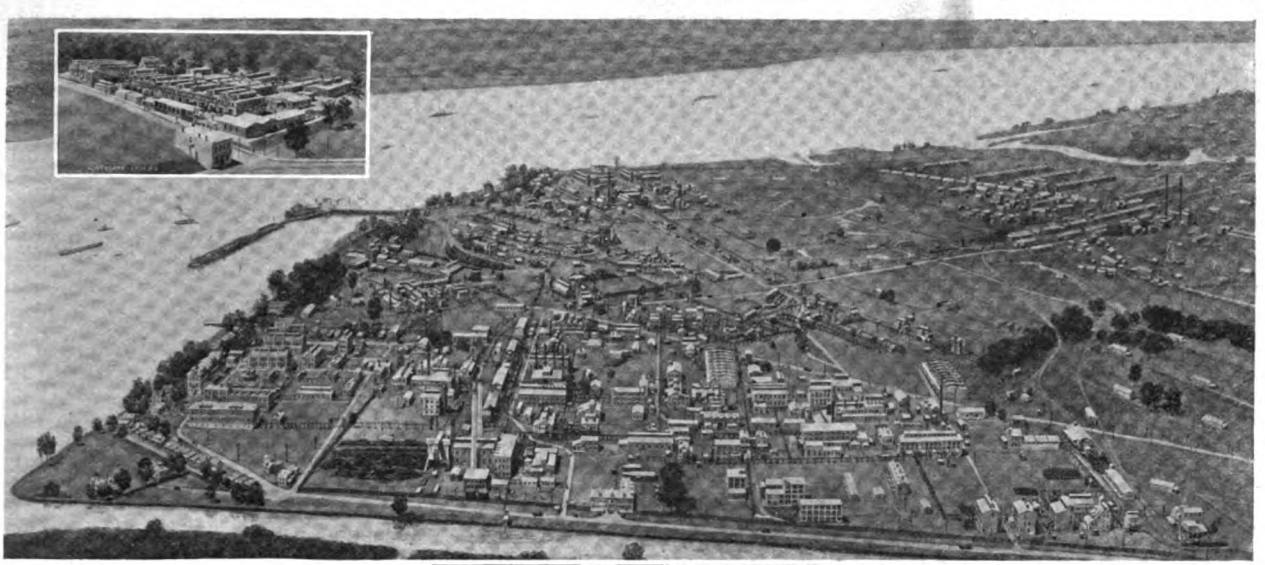
These are not by-products, but their manufacture is more or less closely related to the manufacture of explosives. This relation may rest upon identity of raw materials or intermediates and the similarity of processes and equipment required in manufacture. For example, the sporting



The Repauno dynamite works at Gibbstown, New Jersey, is the largest plant of its kind in the world.

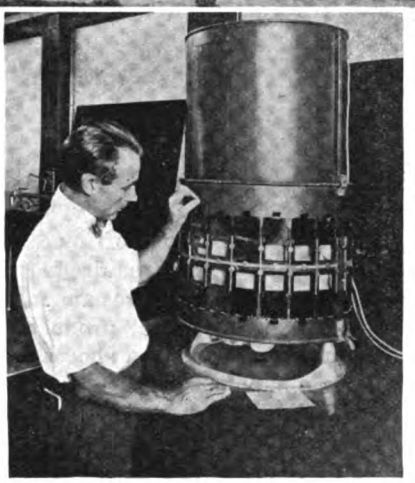
This plant (a section of which is shown in the panorama view on this and on the opposite page) covers an area of 933 acres, with 1,400 acres additional held in reserve for isolation and possible future expansion, and has a capacity of 60,000,000 lb. of dynamite a year.

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A bird's-eye view of the du Pont dyeworks at Deepwater, N. J.

The feature of particular interest here is the widely separated buildings, generally of small size. Isolation is necessary because of the fire hazard and the explosive nature of some of the intermediate products, as certain steps in the dye-making process are quite similar to those employed in the manufacture of explosives. Before the recent war the United States was dependent upon foreign countries, largely Germany, for its dyestuffs and necessity forced American manufacturers, including the du Pont Company, to enter into their production. The importance of dyestuffs is well shown by the fact that twenty-four major industries, employing more than 1,000,000 persons and with many other industries dependent upon them, are dependent upon an uninterrupted supply of dyestuffs. A fade-ometer (to test the fastness of colors to light) is shown in the small illustration at the right.



powder used in shotguns has nitrated cellulose (cotton or other cellulose material treated with nitric acid) as one of its essential ingredients. The nitration of cellulose by slightly different methods and to varying degrees of nitration is also required for the preparation of one of the essential ingredients of photographic film, leather substitutes such as fabrikoid, enamels, pyroxylin lacquers, and the various nitrocellulose colloids such as the nitrocellulose camphor colloid, known as pyralin, which is manufactured into all sorts of useful as well as ornamental materials. While the processes of manufacture and the products obtained from these closely related lines are not identical, nevertheless the similarity is sufficient to make their common production a logical undertaking.

The relation of the manufacture of paints, varnishes and colors to explosives lies in a common interest in the production of certain so-called "heavy chemicals" although a more intimate tie exists between the paint and color industry and the so-called chemical mixture business. Also, the manufacture of colors has a close relation to the production of dyes.

Many of the chemical processes involved in the manufacture of explosives, pharmaceuticals and dyes are closely related or in some cases identical. Because of this close similarity of many of the reactions involved and the rather close relation of much of the chemistry which concerns itself with the dyes and explosives, the du Pont company found a related



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Two steps in making pyralin.
In the rolling operation (above) the "colloid," as received from the mixing room, is manipulated on pairs of large steel rolls to obtain uniformity and distribution of color. Polish is imparted by placing each piece between two smooth, nickel plates and subjecting it to the proper amount of heat and pressure. This operation (at the right above) is known as press polishing. Pyralin material is tough, hard, solid and practically unbreakable and will not corrode, tarnish, decay or rust. It can be manipulated or worked in almost any way without cracking or splintering and takes a polish easily or may be left rough or dull. It can be made in any color and as clear as glass and is usable in many places where it is not desirable or practicable to use glass as in automobile curtains.



A view of part of a chemical laboratory in a dyeworks.
Extensive chemical laboratories are necessary for experimental work and for determining the quality and characteristics of the materials used in production in any of the chemical processes. Practically all of the du Pont products are made by chemically-controlled processes in the sixty plants operated.

field of expansion in the development of an extensive dye industry.

The manufacture of leather substitutes, such as "fabrikoid," has become a big industry. They are used in a variety of places where leather is not required or cannot be used and are an instance of how chemical products can be utilized to meet a shortage in natural supplies.

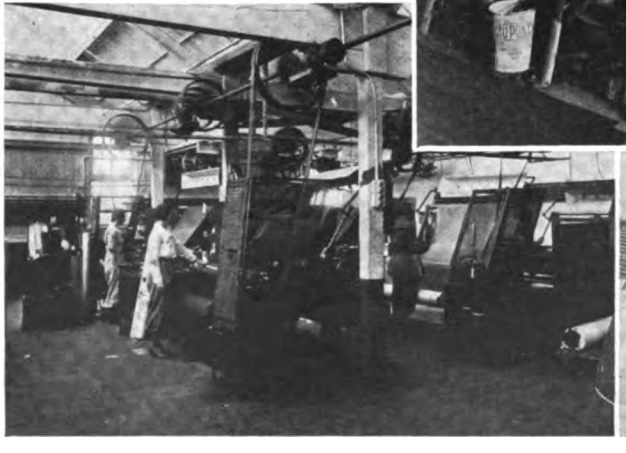
Pyroxylin plastics, like "pyralin," are another development of the American chemical industry and are finding extensive use.

The manufacturing activities of the du Pont Company are divided into six main departments, principal products of which are: explosives, smokeless powder, dyestuffs, cellulose products, "pyralin," and paint. The improvement and better application of these products is maintained through numerous important research and technical laboratories. The Company operates about sixty plants in the United States, located with reference to markets and supplies of raw materials.

Inspecting fabrikoid, a leather substitute.
According to 1919 census, $26,282,000 worth of leather substitutes were made by seventy establishments in the United States. The majority of American-made automobiles are upholstered and trimmed with leather substitutes. Furniture manufacturers likewise use leather substitutes for upholstering. They are used in the manufacture of suit cases, briefcases, traveling bags, trunks. Millions of books are bound with them. In addition, pillows, dolls, and many article are made of leather substitutes, which are waterproof, not easily torn nor attacked by insects.

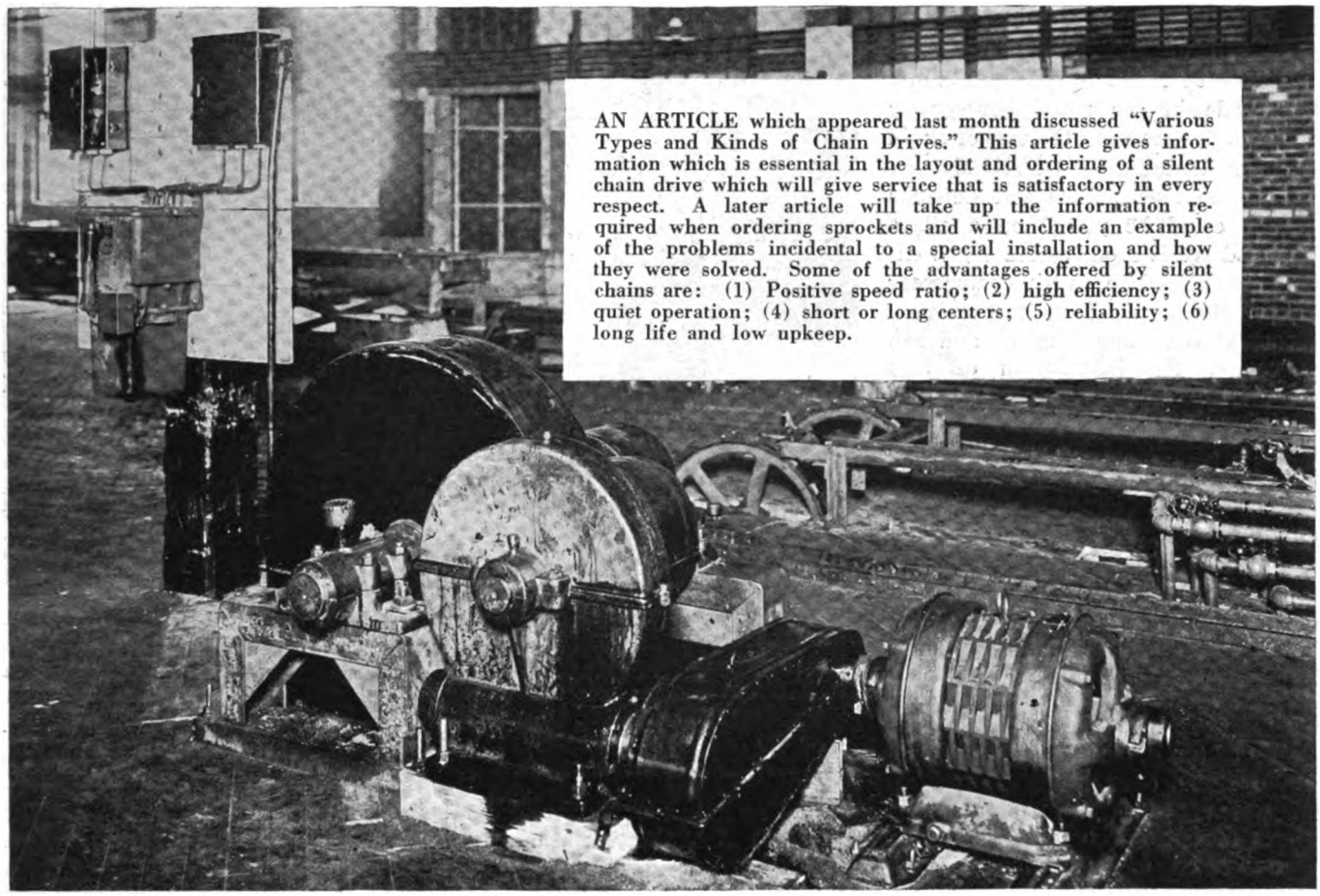


Two views in the paint works of the du Pont Company, at Philadelphia.
In the illustration at the left, the operator is grinding industrial samples of paint. The men in the laboratories make up samples of the precise color and ingredients needed for specific purposes. In the illustration below the operator is mounting, by machine, the "chips" on color cards.





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AN ARTICLE which appeared last month discussed "Various Types and Kinds of Chain Drives." This article gives information which is essential in the layout and ordering of a silent chain drive which will give service that is satisfactory in every respect. A later article will take up the information required when ordering sprockets and will include an example of the problems incidental to a special installation and how they were solved. Some of the advantages offered by silent chains are: (1) Positive speed ratio; (2) high efficiency; (3) quiet operation; (4) short or long centers; (5) reliability; (6) long life and low upkeep.

Assembly conveyors in automobile factories are often operated at a speed of 1 r.p.m. or less. Here the conveyor is driven from a motor through a silent chain, a worm reduction and a gear reduction.

Some Points to Be Checked Up on

Operating Conditions Affecting Chain Service

And Taken into Account When Ordering and Installing Chains on Industrial Drives to Meet These Conditions

By FRANK E. GOODING

Associate Editor, Industrial Engineer

CHAIN DRIVES, properly selected, installed and lubricated, have operated continuously for years without giving trouble or costing a cent for repairs. With chains, as with practically any other mechanism, perfect operation is not due to good luck but results from the application of foresight and judgment in the choice and installation of the mechanism and its care when in use. One of the most important points for the industrial man to consider is the selection of a chain of the right size and type for the work to be done.

Chain manufacturers issue booklets of engineering data covering the points to consider when determining the type and style of chain that is best suited to the drive conditions. Since chain construction is not standard for all types and styles no specific information can be given that applies to all makes. When working out the first chain installation it is well to call on the manufacturer for advice and a check-up on your own estimates. As a basis for determining the proper size, the manufacturer will need the information given in the box on page 380 which outlines the service conditions surrounding the particular installation.

In discussing these points of information in sequence, the first is, of course, the horsepower to be transmitted. For this, it is always advisable to give the maximum rating of highest load which may be applied. Peak load conditions should always be considered in selecting any equipment, for that matter. If the peak load is applied only infrequently or momentarily, as at starting, the chain may be rated at maximum running load as the chain is several times stronger than the load which may be applied to it because a chain has a factor of safety of ten or more. Ultimate strength is of secondary importance as metal parts never are loaded near this breaking point. However, this does not mean that a chain may be continuously loaded above its rating with impunity.

Where shock loads are frequent, as

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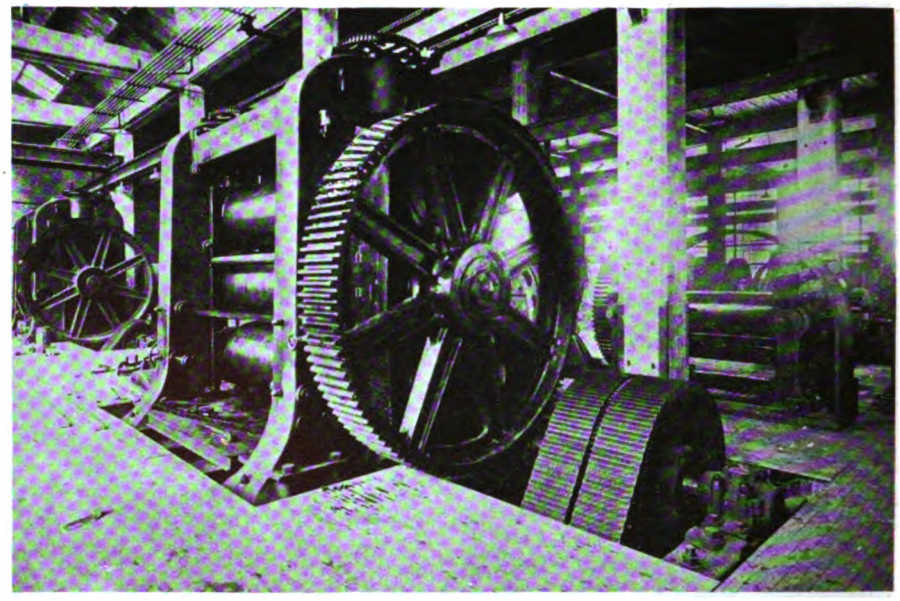
on air compressors, gas engines and similar equipment, an additional allowance of 10 to 50 per cent must be made in the rated horsepower used in determining the size of chain for the installation. Probably one of the most severe service conditions which could be placed on a silent chain drive is a one-cylinder gas engine connected to an air compressor where the pulsations from both may come at the same moment and are opposite. An installation of this type is not recommended unless provided with flywheels of adequate size to give sufficient balance and absorb the shock load.

The proper allowance to make in any shock load installation is largely a matter of experience and judgment and dependent upon the maximum momentary strains that may be developed, the frequency of their repetition and whether the full load remains for some time. Under these conditions the manufacturer of the particular type of chain selected can offer, through its engineering department, the best advice. It is always advisable to seek this consultation service because it is given by experts who can often give additional suggestions which tend toward economy in installation and operating cost.

One of the big advantages of chains is the flexibility of the center distances. Ordinarily a chain should have a distance between centers equal to the diameter of the large sprocket plus one-half the diameter of the small sprocket. It is usually best to increase this somewhat, however. Chains operated on sprockets with about 25-ft. centers or over, should be supported on idlers or better still, divided into two or more drives by using additional sprockets and shafts. Also when several parallel shafts are to be driven by one chain, it is preferable to divide the drive into shorter individual drives.

Another important factor to be considered is the speed ratio. Probably the best operating ratio is between 6- or 8-to-1 and most installations may be operated somewhere within these limits. Many installations have been operated successfully at much higher ratios, however, where the chain speed is not excessive. It is better to use a lower speed motor or other driving mechanism than to try to make excessive reductions through chain drives.

Unless an exact speed ratio is absolutely necessary, it is best to indicate how much variation is permissible. A slight variation does not make any great difference and it is often possible to get a much better selection of sprockets without using one with an extra small number of teeth, or using a chain with pitch unsuited for the conditions under which it operates. If the surroundings are such as to limit the diameter or width of either sprocket, it is necessary to note these so that the manufacturer will not recommend a size which could not be installed.



A 300-hp. chain drive installation in a rubber mill.
Here two 1½-in. pitch silent chains 14 in. wide on 96-in. centers connect the motor, which is placed in the basement, to a shaft geared to a rubber calender with a speed reduction from 600 r.p.m. to 105 r.p.m.

In choosing a chain for any installation, the user frequently has the option of several different combinations of widths and pitches. For example, a chain of ½-in. pitch, 2 in. wide, another of ⅝-in. pitch, 1½ in. wide, and a third of ¾-in. pitch and 1¼ in. wide will transmit the same power. Generally, in such cases, it is best to use a wider chain of less pitch although narrow chains of longer pitch would be somewhat cheaper. The larger sprocket may be more expensive, however. Chain

Information Necessary to Determine Proper Size of Chain Drive for Industrial Purposes

Horsepower (Maximum).....

Must speed ratio be exact?.....

	DriveR	DriveN
Rev. per min.....		
If induction motor give full speed...		
Max. sprocket dia. (including chain).		
Max. sprocket face.		
Max. shaft space available		
Diameter of shafts.		
Width and depth of keyways		
Split, yes or no....		

Make sketch showing relative positions of driveR and driveN sprockets, indicate driveR, directions of rotation and floor line.

Number of hours service per day....
How much of time at full load?....

Distance between centers of shafts.. .....

Can centers be adjusted?.....

If so, how much?.....

If not adjustable, can centers be set to suit an even number of links in the chain?.....

The chain drives from { Electric Motor / Gas Engine / Lineshaft / Steam Engine / Water Wheels } to

Will it be used in a dry, wet, dusty or gritty place?.....

Is the chain pull steady or pulsating? .....

If compressor, pump or gas engine, give number of impulses per revolution.....

Does drive reverse? .....

If drive replaces gears, belts or other chains give complete description of same.....

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A 150-hp. motor connects a line-shaft to a copper wire drawing bench.

Transmission is made by a 1½-in. pitch silent chain 13 in. wide from a motor operating at 600 r.p.m. The line-shaft operates at 137 r.p.m.; this is obtained through 19 teeth in the motor pinion and 83 teeth in the sprocket.

widths of from 2 to 6 times the pitch are recommended. As dependability and low operating costs are the principal factors in chains, as in any other mechanical or electrical installation, rated capacity, speed or other operating limitations should not be exceeded in an attempt to economize in first cost.

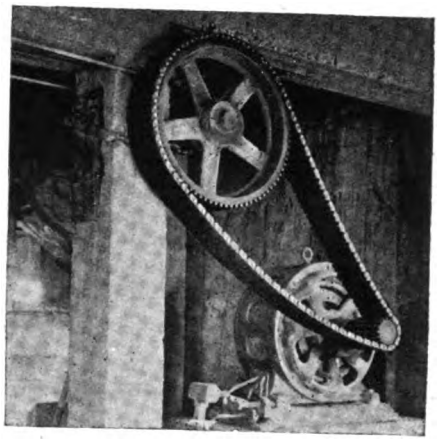
To obtain extremely quiet operation as is required in schools, churches, offices, and similar places, wide chains of short pitch are used on sprocket wheels of not less than 17 to 23 teeth and at a lower chain speed and revolutions per minute than is ordinarily rated for the power transmitted.

Motors connected by chain drives should always be mounted on adjustable baseplates to permit the adjusting of the center distance to take up any slight wear or elongation of the links and also to permit of sufficient adjustment so that an even number of links may be used without permitting too much slack. When center distances are fixed or on vertical drives, it is some times necessary to use a "hunting" or "offset" link—a special link where three links replace four and make an odd number of links or pitches thus shortening the chain by one pitch. It is not possible to get a fractional pitch. Also chains should not be installed so short that they make tension on both sides when idle because it is never necessary and also is hard on the bearings. One of the advantages of chain drives is the freedom of an extra tension, merely to give traction, in addition to the tension arising from the pull due to transmitting power. When idle, the only tension on the chains and bearings should be the small amount due to the weight of the chain.

If a chain drive is to replace another drive a careful description of the former conditions will serve as a check on specifications and service conditions on the installation. However, if the new installation is to have increased power, higher speed, or other changes in the service conditions such facts might well be noted in addition to the other description. It is also well to show the relative position of the sprocket with respect to the floor line as special considerations must be taken into account on vertical drives, particularly if the small sprocket is below. Also it is well to note in this drawing any shafts or other projections which might interfere with the operation of the chain.

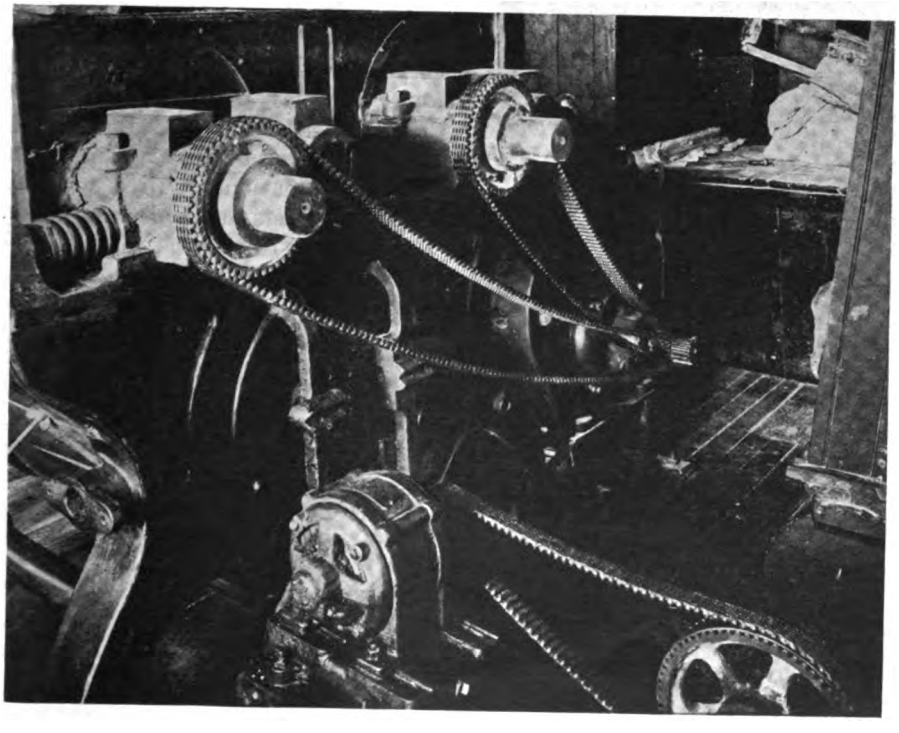
When ordering a new chain to replace an old one it is not sufficient, usually, to count the links and order the same number of links in the new chain. For example, suppose a chain originally 100 links long has elongated 1 or 2 per cent during its life so that one or two links have been removed. If a new chain is ordered 98 or 99 links long, the length of the present installation, instead of 100 links long, it will be too short and necessitate a re-order. Complete information must be given on even a re-order so that the required length may be calculated as a check on the specifications listed in the order.

In order to select the most economical chain drive for any particular installation the several possible combinations of different speeds of motor with different sizes of chains and pinions must be considered. A good example to bring this point out is the following case given by Eustace C. Soares,, Electrical Engineer,



A motor connected to an overhead shaft in a mill installation.

When the large driven sprocket is placed above the smaller pinion provision must be made so that any wear or slack may be taken care of. Ordinarily this may be done by adjustable base plates or by removing a link from the chain.



Three silent chains in an elevator installation.

Here two chains driven from the same motor pinion are attached to different shafts in an elevator mill. In this way it is possible to get absolute speed relationship in the operation of the two shafts without extensive gearing. The small chain in the lower part of the picture drives an elevating conveyor.

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Cost of 7½ H. P. Motor and Chain Drive When Motors That Operate at Different Speeds Are Used

Motor Speed, R. P. M.	Number of Teeth		Cost		
	Motor Pinion	Pump Pinion	Motor	Pinions and Chain	Total
600	17	69	$325	$ 59	$384
720	17	81	275	70	345
900	17	102	265	78	343
1,200	17	135	239	107	346

Ophuls and Hill, Inc., New York City, of a motor-driven pump which was recently installed in an ice plant in New York.

In this connection it may be well first to say something about the conditions which led to the selection of chain drive. The pump, which is shown in an accompanying illustration, was originally driven by a direct-current motor direct connected to a 6-to-1 ratio geared shaft.

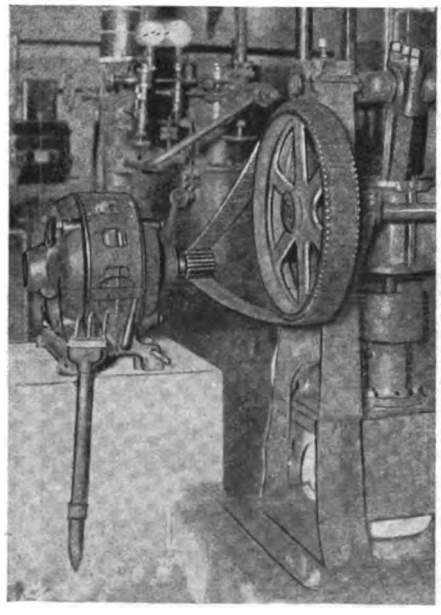
The motor was rated at 15 hp., 400 r.p.m., although the actual power required to drive the pump was about 6 hp. As the motor speed was too high, resistance was introduced in the armature circuit to reduce the speed. This was, of course, very inefficient.

The duty of this pump was to pump liquid from a receiver into a circulating system. At times the pump would do no work while at other times it would be doing its full work. If the pump was running under full load and the load went off the speed would increase about 100 per cent. Should the load come on again water hammer would be produced which might become serious. This drive was, therefore, objectionable on account of the large amount of attention required.

It became necessary to convert this drive to alternating current. Three types of drive were open for consideration; (1) direct drive, (2) belt drive with or without an idler and (3) chain drive. Direct drive was out of the question as it would be necessary for the motor to run under 200 r.p.m.; belt drive, while cheap, would not have been in keeping with the appearance of the other equipment.

Chain drive was finally decided on. Here the question of the speed of the motor came in because the higher the speed of the motor for the same horsepower the cheaper the price. First, a minimum limit of a 17-tooth pinion was fixed for the motor to insure a satisfactory drive. This point being decided it was then necessary to determine the size of the driven pinion mounted on the pump. With increasing size of this pinion the permissible speed of the motor increases and the price of the motor decreases. However, a limiting point is reached where the increased cost of the large pinion is more than the decreasing cost of the motor and *vice versa*. The balance between these costs was worked out for several different speeds of motor. The accompanying table shows the figures for four different speeds. It may be seen from this table that the price of the motor decreases as the speed increases. However, the price of the pinions and chain increases as the speed increases largely because of the increase in size of sprocket to give the proper reduction ratio.

There is not much to choose from between the last three speeds (720, 900 and 1,200 r.p.m.) so far as price is concerned. However, in this case the 900 r.p.m. outfit was used in preference to the 720 r.p.m. outfit because it was easier to obtain this motor, and in preference to the 1,200 r.p.m. outfit on account of the decreased chain speed and the lower speed reduction ratio which would be obtained.



A 900 r.p.m. motor was found to be cheapest for this pump drive as shown by the table at the top of the page.

It is advantageous to inspect all roller chain and sprockets frequently. This need only take a few moments as it is not necessary to remove the chain. Look for broken or cracked rollers; inner side plates worn badly, which indicate poor alignment of sprockets or teeth too thick; links showing undue looseness, which indicate broken bushings or excessive pin wear; pins loose in the pin plates. Repair all defective parts immediately. Chains may run fairly well for a time with several rollers missing, but in the long run this is destructive both to sprockets and to the neighboring links. It is advisable to renew the entire roller link whenever a broken roller is discovered. Never attempt to take the roller link apart and merely put on a new roller. These roller links are assembled with great care and have just the correct amount of press fit between bushings and inside plates, as well as the correct dimensions over the side plates, and they can not readily be repaired without destroying these conditions. New roller links can be purchased cheaper than this repair can be made.

Where new industrial drives are contemplated or old drives are giving trouble or if for any other reason changes are considered in the transmission units it may pay to investigate the use of chains. They have been tried out in practically all industries and have many advantages as mentioned in this and the previous article. Another article will take up information required when ordering sprockets and a description of the problems incidental to a particular installation.

Editor's Note: Special acknowledgement is made to Earl C. Moss, Consulting Engineer, Chicago, Ill., and to the following companies for their kind assistance in furnishing information and photographs for this and the previous article on this subject: American High Speed Chain Co., Indianapolis, Ind.; The Baldwin Chain & Manufacturing Co., Worcester, Mass.; Cullman Wheel Company, Chicago, Ill.; Diamond Chain & Manufacturing Co., Indianapolis, Ind.; Duckworth Chain & Manufacturing Co., Springfield, Mass.; The Jeffrey Manufacturing Co., Columbus, Ohio; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; The Whitney Manufacturing Co., Hartford, Conn.

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THIS SHOWS PART of the storage space for motors in the plant of the Gregory Electric Co., Chicago, Ill. In this article there are described the repair methods and the routine of handling the work which passes through the plant. These methods and order systems are based on thirty years of experience in repairing and rebuilding all kinds of industrial electrical equipment.

Details of Procedure in

Repairing and Rebuilding Electrical Equipment

In a Plant Which Has Specialized in This Kind of Work for Thirty Years

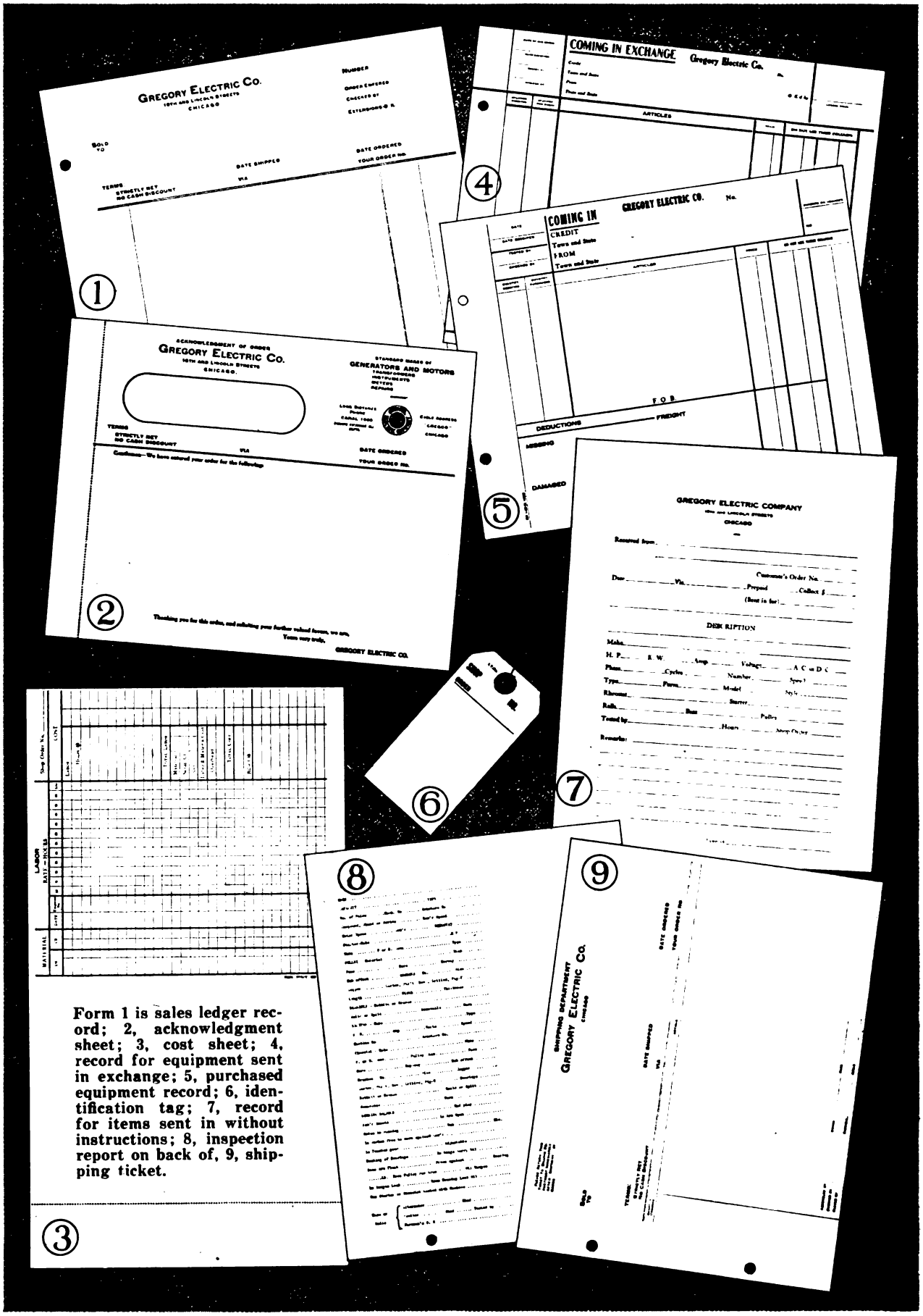
By J. D. ZOOK
Superintendent, Gregory Electric Company, Chicago, Ill.

REPAIR METHODS, routing of the work and the report and order forms used in the plant of the Gregory Electric Co., Chicago, Ill., are the result of thirty years of experience and endeavor to devise the best and simplest procedure for handling the wide variety of work which is done there. We buy used or damaged electric motors, control apparatus, transformers, meters and other kinds of industrial electrical equipment and rebuild it for resale. We make in our own shop most of the repair parts needed, such as bearings, commutators, and so on. In addition to this work, which is the backbone of our business, we rent out large numbers of motors and generators and do a good deal of commercial repairing of equipment. The fact that these activities involve the handling and repair of practically all makes, types and sizes of motors and other equipment renders it more difficult, and yet all the more necessary, to have simple but effective shop and office methods. The nature of our business makes it necessary for us to do our work thoroughly and with maximum efficiency.

All shipments of heavy equipment are received or sent out on a switch track which runs through one side of our plant. Pick-ups and deliveries around the city are made by motor trucks, in the case of equipment which is not too heavy to be handled in this manner. As soon as notice is received of an incoming shipment of motors or other equipment, the shop order clerk assigns an order number and makes out the tag shown in Group *A*, Fig. 6. The order number is a serial number and all charges are made against it. This

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Group A, Office Records, Labor and Material Forms



Form 1 is sales ledger record; 2, acknowledgment sheet; 3, cost sheet; 4, record for equipment sent in exchange; 5, purchased equipment record; 6, identification tag; 7, record for items sent in without instructions; 8, inspection report on back of, 9, shipping ticket.

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tag is sent to the shipping department and when the motor or whatever it may be comes in, the tag is attached to it and serves as an identification mark as the article goes through the various plant departments, including finished storage.

Motors and other equipment may be sent to us under any of the following conditions: (1) We have previously arranged to purchase the items. (2) They are for sale and have been submitted for examination. (3) They have been sent in for repair. (4) They have been sent in in exchange for other equipment.

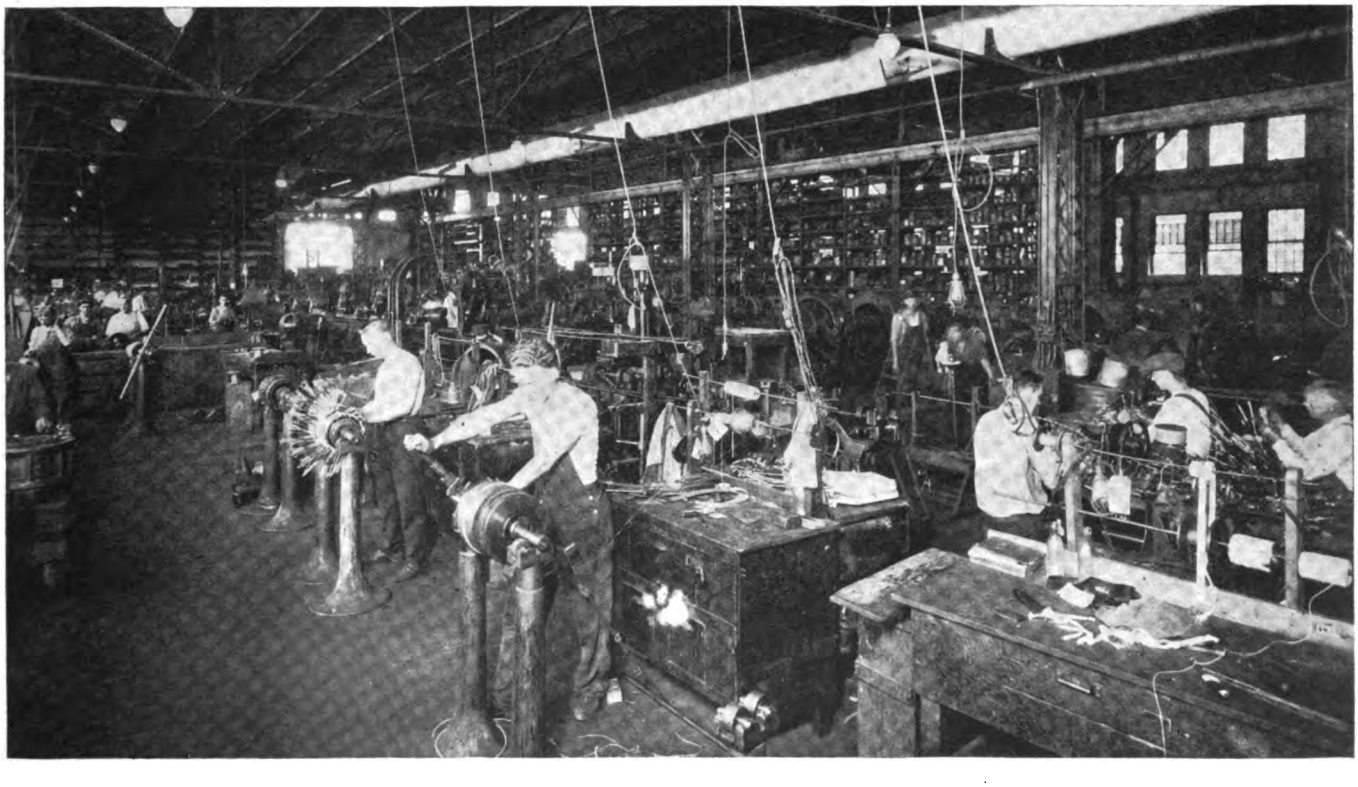
When equipment is sent in for repair, or if previous notification of shipment and advice as to whether it is to be repaired or is submitted for sale has not been made, one copy of the white form shown in Group *A*, Fig. 7, is made out and held until we can determine what the owner wishes to have done with the shipment. It frequently happens that motors and other apparatus are sent to us for one reason or another, but the owner either forgets to notify us that he has made such a shipment and state what his wishes are, or his letter goes astray. Without some record such as is given by this form a good deal of confusion and perhaps loss might result, as it may be several weeks before we know what to do with the shipment.

If the equipment in question has previously been purchased by us, a *Coming In* order is made out on the orange-colored form shown in Group *A*, Fig. 5. This orange sheet is sent to the shipping department and held until the material comes in. The receiving clerk checks the shipment for quantity or number of pieces and notes at the bottom of the sheet any parts which are missing, as well as any damage which has been done in transit. In the latter event, a damage claim is filed with the railroad company. The same procedure is followed in the case of equipment which is offered to us for sale. We make an examination and notify the owner what we are willing to pay for the equipment, which is then stored until he either accepts or rejects our offer.

If the equipment has been sent in in exchange for other equipment, a pink *Coming In Exchange* sheet Group *A*, Fig. 4, is made out instead of the orange sheet.

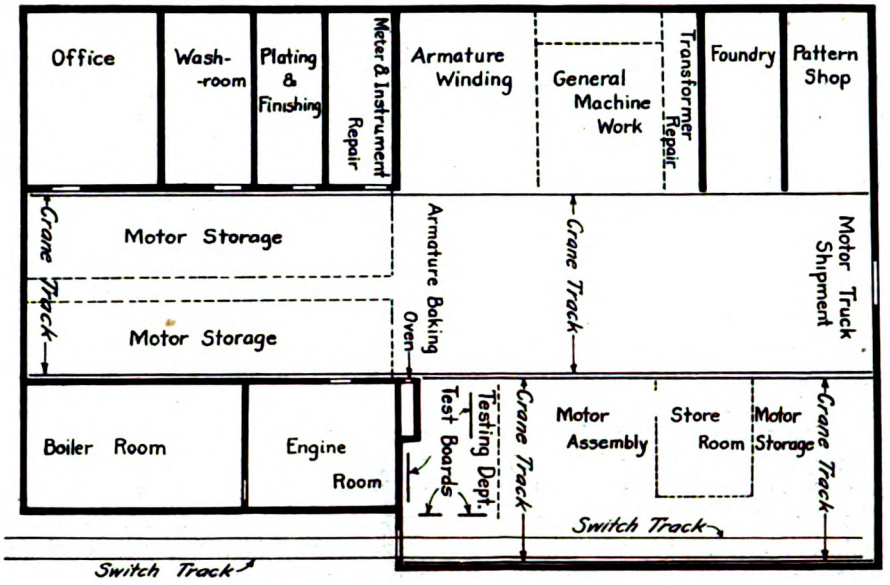
Every piece of equipment which comes into our plant is, then, first sent along with the orange shipping ticket, to the testing department where it is operated and tested to locate and determine the nature of any defects which may be present. In this department there are three main testing boards from which we can obtain any commercial voltage in direct current and any voltage, frequency and number of phases of alternating current, that may be needed to test any commercial piece of equipment. In addition to the instruments mounted on the switchboards the testing and inspection department is well equipped with portable types of indicating and recording instruments. In the case of a motor if any of the coils are burned out or grounded or other defects are found, the inspector makes note of them at the bottom of the sheet. The motor is then disassembled and the bearings, coils, commutator, shaft and so on are carefully examined. If a new commutator is required or the old one needs turning, or other repairs should be made, they are likewise noted. This sheet, which thus contains a complete record of the repairs needed on the motor, is then turned over to the superintendent for his approval.

If, in his opinion, the repair work specified on the sheet is needed and is justifiable in every way, he O. K.'s the sheet and the motor is sent to the department which is to do the work. In this way the superintendent is enabled to keep close watch on equipment which is purchased and also on all work which is done in the shop. We frequently



Armatures and small stators are rewound in this department.
The coil winding, spreading and taping machines can be seen at the right. At the extreme left a workman is testing out a rewound armature at the testing board. Each winder has his own bench fitted with drawers which can be locked and in which he keeps the tools used in his work. In the center background is a large rack in which is stored the stock of pulleys.

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Floor plan of factory, showing location of different plant departments.

receive motors and other equipment which are not worth repairing. That is, the investment in labor and material necessary to put them in first-class condition would not be justified by the price for which we can sell an equally good machine. In such cases, we dismantle them and sell the material for junk, or if it is a repair job the customer is notified.

As is shown in one of the illustrations, which gives the layout of our plant, there are several separate departments each of which is devoted to a certain phase of the repair work.

The armature-winding department is provided with Armature Coil Equipment Company's coil-winding and spreading machines, Segur taping machines, a test board from which can be obtained any voltage from about 28 volts to 4,000 volts, and the other equipment which is necessary in order to handle properly a wide variety of armature and small stator winding. Coils for large stators are wound in the transformer repair section.

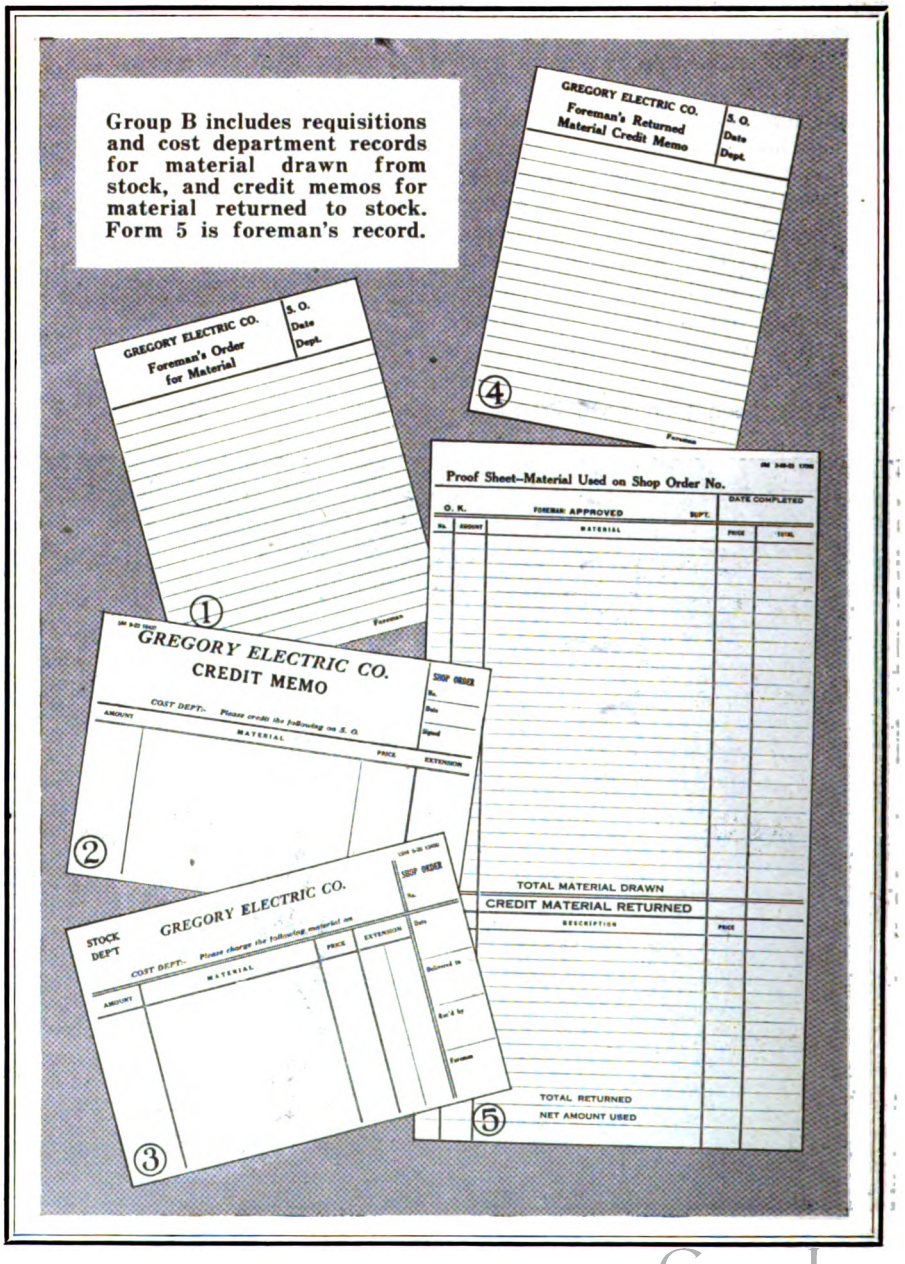
Another section is devoted to commutator work. Here commutators which need turning or other attention are put into good condition. If a motor needs a new commutator it is made in this department. The segments are cast in our own foundry, then put together and the commutator is turned to size finished and carefully tested.

The machine shop, which is well equipped with lathes and other machine tools, all of which have individual motor drive, handles the miscellaneous machine work required, such as turning shafts, making new bearings and so on. We cast all of our own bearings in the foundry.

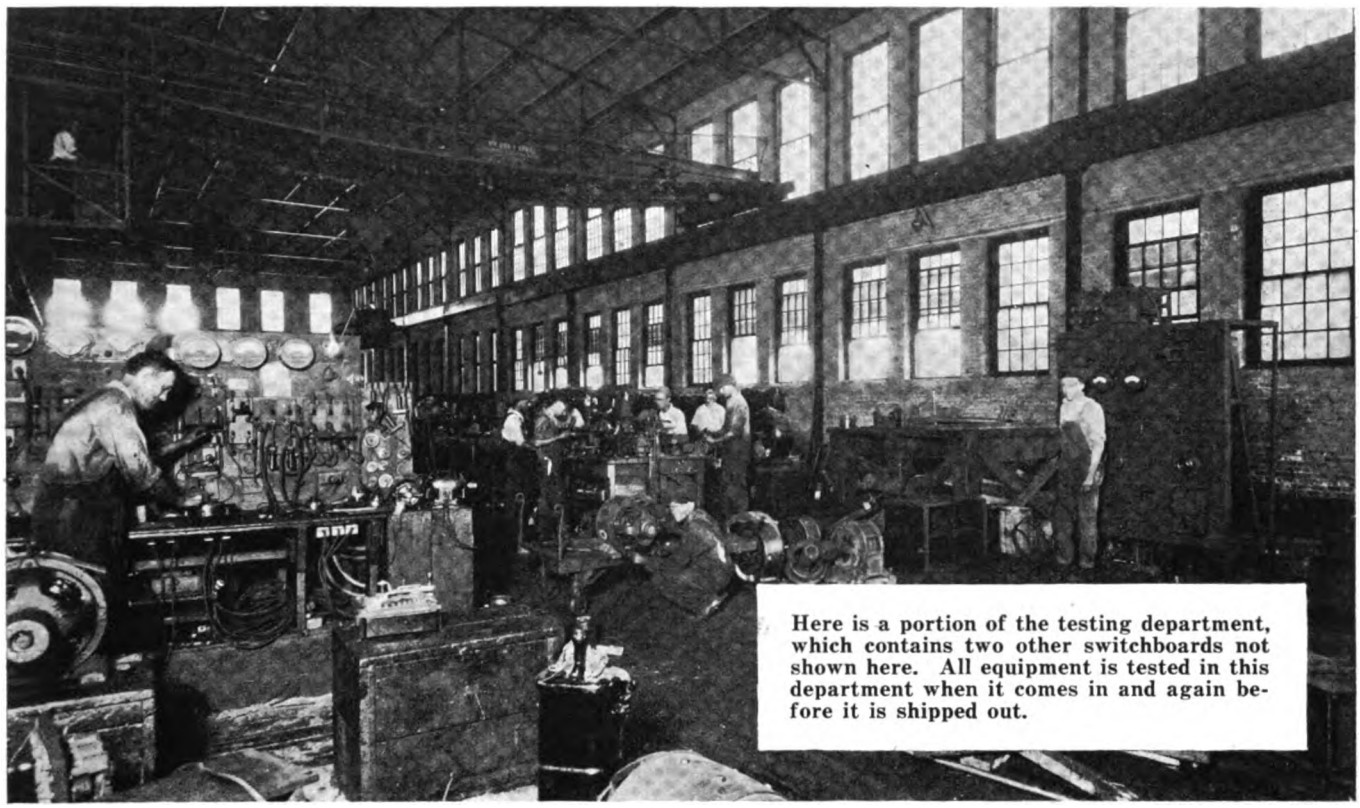
Patterns for commutator segments, bearings and other parts are made in another section which is devoted to this work.

In the transformer section, transformers and starting equipment are thoroughly overhauled, and defective coils or other parts replaced.

The meter department is equipped with the fine machine tools necessary for overhauling and rebuilding all kinds of electrical indicating and recording instruments. Testing and calibrating are an important part of the work of reconditioning meters and indicating instruments. In addition to the necessary, carefully-calibrated standard instruments there are available two motor-generator sets. From one of these any voltage from about 1 to 350 can be obtained: the other will furnish from 350 to 750 volts, so that combining the two we can get up to 1,100 volts, direct current. Transformers are used to



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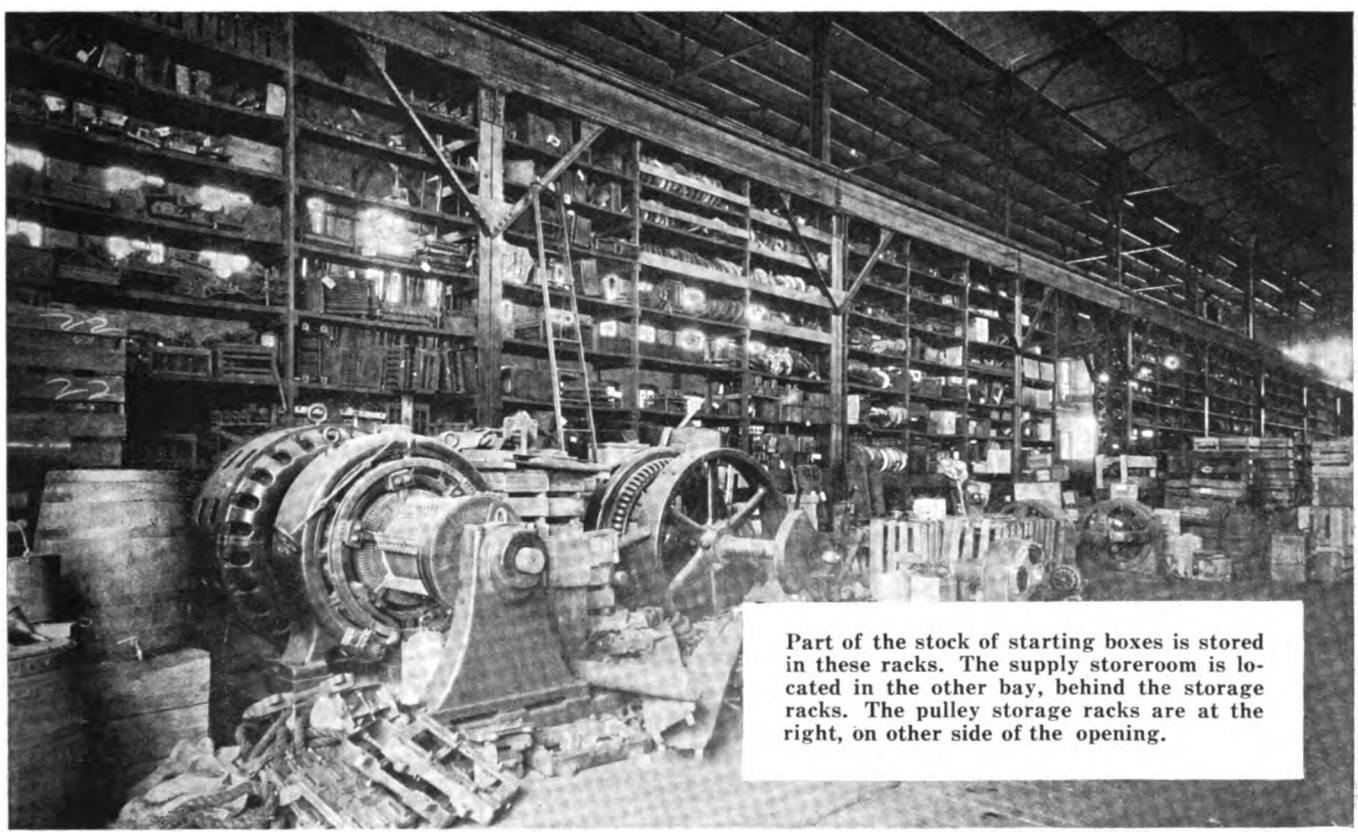


Here is a portion of the testing department, which contains two other switchboards not shown here. All equipment is tested in this department when it comes in and again before it is shipped out.

supply alternating current of any desired voltage. Besides these, we have a large plating generator from which we can obtain low-voltage current of any desired amperage. As an indication of the amount of work done in this department from 3,000 to 5,000 instruments are repaired or completely rebuilt each year.

As will be seen from the plant layout, the storeroom is centrally located so that it is convenient to all departments. Handling, as we do, anything from a fan motor to 200- or 300-kw. motors and generators, transformers, starting equipment and so on, makes it necessary to carry in stock a wide variety of replacement parts and supplies, in sufficient quantity to meet any probable demand. This stockroom is enclosed, all withdrawals must be made on properly approved requisitions and in general we feel that we have an efficient system of handling this department of the plant.

In order to operate and test the



Part of the stock of starting boxes is stored in these racks. The supply storeroom is located in the other bay, behind the storage racks. The pulley storage racks are at the right, on other side of the opening.

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machines and equipment which is purchased or sent in for repairs, it is necessary to have available direct current at various voltages and single-phase, two-phase and three-phase alternating current of various frequencies and up to 10,000 volts. We find it advisable, therefore, to generate our own current. Our power plant contains the following units: One 100-kw., 220-volt, engine-driven, direct-current generator; one 75-kw., single-phase, engine-driven, 2,300-volt, alternating-current generator; one 20-kw., 250-volt, motor-driven, direct-current generator; one 50-kw., three-phase, 2,200-volt, motor-driven, alternating-current generator; one 220-550-volt, 10-hp., motor-driven, direct-current generator, and one 150-hp. engine, for driving generators under test.

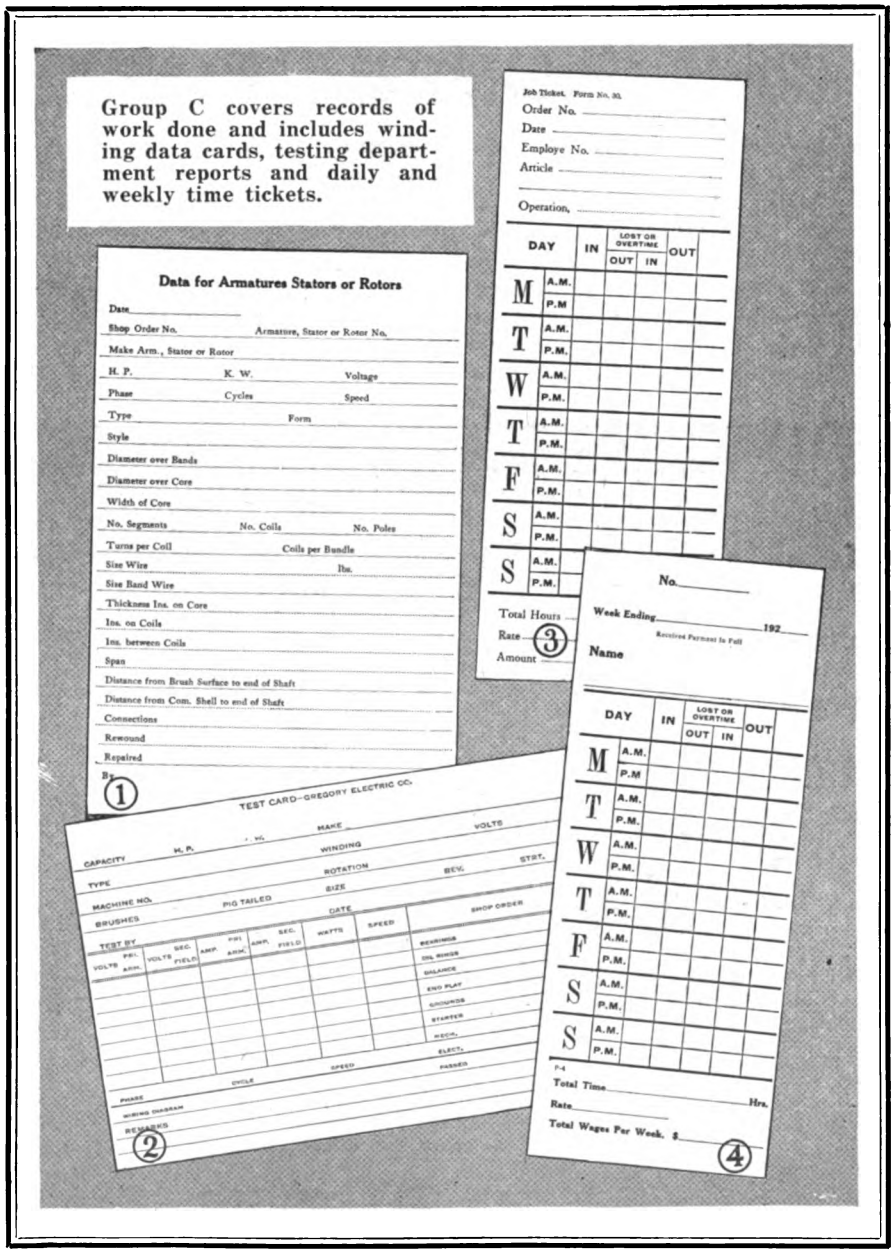
The system of routing orders received for sale, exchange, repair or renting out of equipment is the same in all cases. As soon as the order comes to the entry clerk he enters it, (1), on a white sheet, Group *A*, Fig. 1, in the case of a sale, or on a green sheet for a repair job. This white or green sheet, as the case may be, is filed as the original entry in our sales ledger, after shipment is made. As many duplicate white invoices are made as are required by our customers. (2) On a blank, tissue sheet for our correspondence files. (3) On a yellow, shipping department ticket, Group *A*, Fig. 9. (4) On the tan-colored cost sheet, Group *A*, Fig. 3, for a repair job, or on a pink sheet in case of a sale. (5) On a rose-colored acknowledgment sheet, Group *A*, Fig. 2. These forms are so arranged that they can all be made out, as carbon copies, at the same time.

The routine which is followed when a machine or part is sent through one or more of the plant departments is as follows: As soon as we decide to repair for stock a motor or any other equipment which we have purchased, the cost clerk starts a white cost sheet Group *A*, Fig. 3. A separate sheet is filled out for each operation, such as rewinding armatures, fields or stators, refilling commutators and so on. As was stated previously, if we have already sold that motor the same entries are made on a pink cost sheet, of the same form as the one shown in Group *A*, Fig. 3, while a tan sheet is used for the repair jobs. The nature of the repairs needed has previously been noted by the inspection department on the orange *Coming In* sheet, Group *A*, Fig. 5. After the order is approved by the superintendent, the order and the part, armature in this case, are delivered to the foreman of the armature winding department.

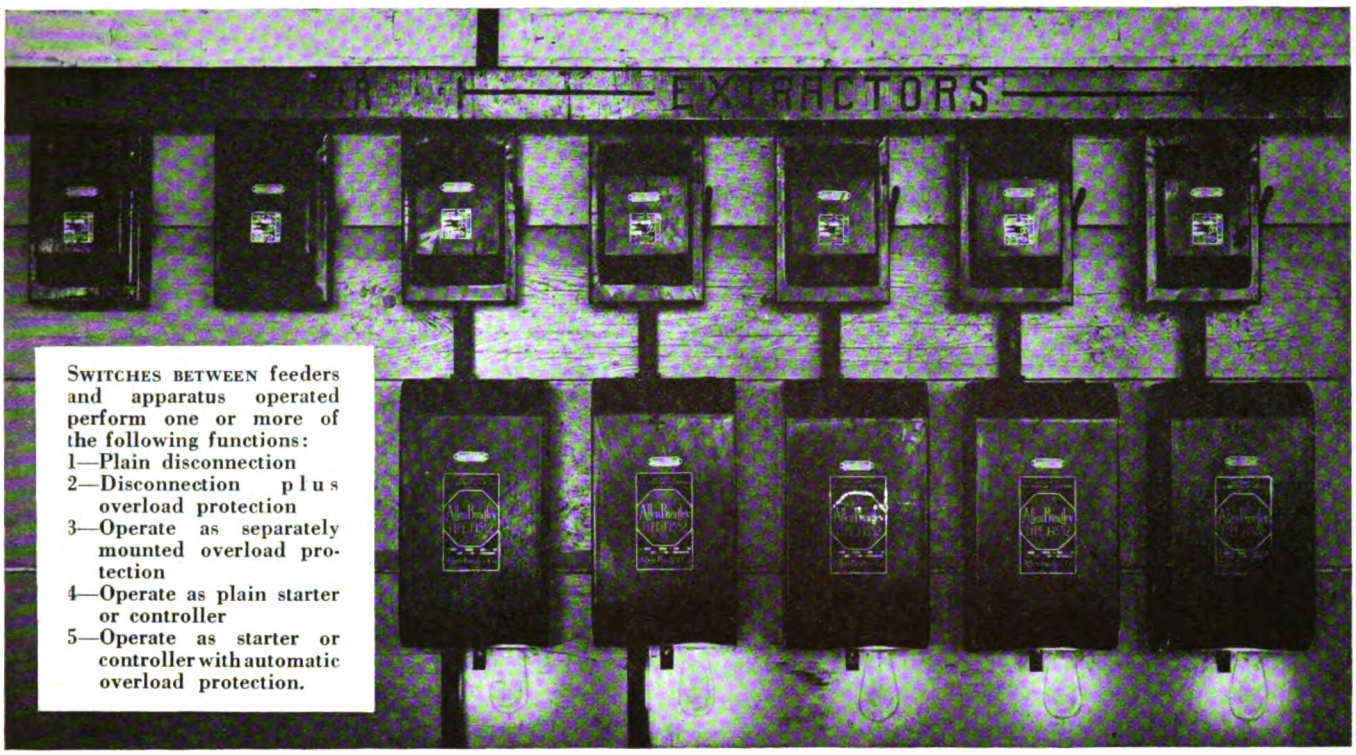
When the job has been assigned to one of the winders, the first step is to fill out the data card shown in Group *C*, Fig 1. As will be seen, this card is one which can be used for armatures, rotors or stators and when properly filled out contains all the information which the repair man needs in order to rewind the part correctly. If a diagram of the connections or other information not provided for on the front of the card is considered desirable, it is put on the back of the card. These cards are carefully filed away and are very useful as reference sheets in checking up a winding in case any doubt or question comes up.

The wire, insulation, and other materials needed for the job is drawn from the stock room on the requisition form shown in Group *B*, Fig. 1. This requisition is signed by the foreman and turned over to the storekeeper. No duplicates or copies are made of this order which, after the material called for has been delivered, is filed by the storekeeper. The foreman has, however, as his record, a proof sheet, shown in Group *B*, Fig. 5, on the upper part of which he enters all materials ordered from stock. Each job has a separate sheet.

Each day, the storekeeper fills out and sends to the cost department, the form shown in Group *B*, Fig. 3. A separate sheet is used for each job on which material has been withdrawn. Each of these sheets is then pasted in the cost department to the labor *(Continued on page 401)*



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SWITCHES BETWEEN feeders and apparatus operated perform one or more of the following functions:
1—Plain disconnection
2—Disconnection plus overload protection
3—Operate as separately mounted overload protection
4—Operate as plain starter or controller
5—Operate as starter or controller with automatic overload protection.

This is a sub-distribution and control installation used with push-button-controlled switches for extractor motors in the San Diego, (Calif.) Steam Laundry.

What Are the Requirements of

Protection That Safety Switches Can Provide

And the Construction Features That Are Essential to Insure That Protection?

By D. H. BRAYMER

Editorial Director, Industrial Engineer

IN INDUSTRIAL works during the past ten years considerable interest has been taken in Safety First movements that tend to prevent industrial accidents. This has been compelled in some instances by workmen's compensation laws and regulations of state industrial commissions and labor departments and by the insurance companies, but in the majority of cases this work has gained recognition because it has an economic reason as well as a humanitarian reason. Every workman has a just right to demand safe and sanitary working conditions. On the other hand, every manufacturing establishment profits in the long run by a reduction of preventable accidents through increased production and the elimination of wastes that accompany unexpected interruptions in processes of production. Continuity of machine operation at a maximum rate of production is an insurance against high production costs that is worth a definite expenditure in any works, large or small. And it is the job of the works superintendent and the heads of his departments to maintain adequate safety in plant operations as a part of their responsibility in connection with continuity of production at a maximum rate and a minimum cost.

In connection with any schedule of production, the continuity of power service to machines and processes of manufacture is just as definite a factor in cutting costs as the elimination of delays in the securing of a supply of raw material for machines to work on.

In this article the elements of protection that insure safety in the manipulation of enclosed externally operated switches at machines, their inspection, repair and maintenance and the resulting economies from the standpoint of the elimination of preventable accidents and interruptions of power service are discussed. The details revolve around the construction of so-called safety switches that are designed and used to cover four phases of protection which are as follows:

1—Protection for workers to prevent contact with live parts of an electric circuit.

Protection Essential with Enclosed Externally Operated Switches

1—Protection for workers to prevent contact with live parts of a circuit.

2—Protection for maintenance men working on electrical circuits or electrical apparatus and for men adjusting, repairing or working on machines liable to be started if current is accidentally turned on.

3—Protection to the electrical apparatus operated and to maintain continuity of service through prevention of electrical failures in circuits and machines.

4—Protection against fires and explosions caused from arcing of the switch.

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2—Protection for maintenance men working on electric circuits or electrical apparatus and for men adjusting, repairing or working on machines liable to be started if current is accidentally turned on.
3—Protection to the electrical apparatus operated and to maintain continuity of service through elimination of preventable electrical failures in circuits and machines.
4—Protection against fire hazard from arcing.

The present use of the term "safety switch" is somewhat misleading unless qualified by the kind of protection that it provides under one or all of these headings.

Protection for maintenance men whose job it is to inspect and repair electrical circuits and equipment and who are usually designated as persons authorized to handle switches is equally, if not more, important than protection for workers at or about machines. By placing enclosed externally operated switches out of easy reach of workmen and locking the enclosing cabinet, together with proper installation and inspection by authorized maintenance men, a wide range of safety is provided.

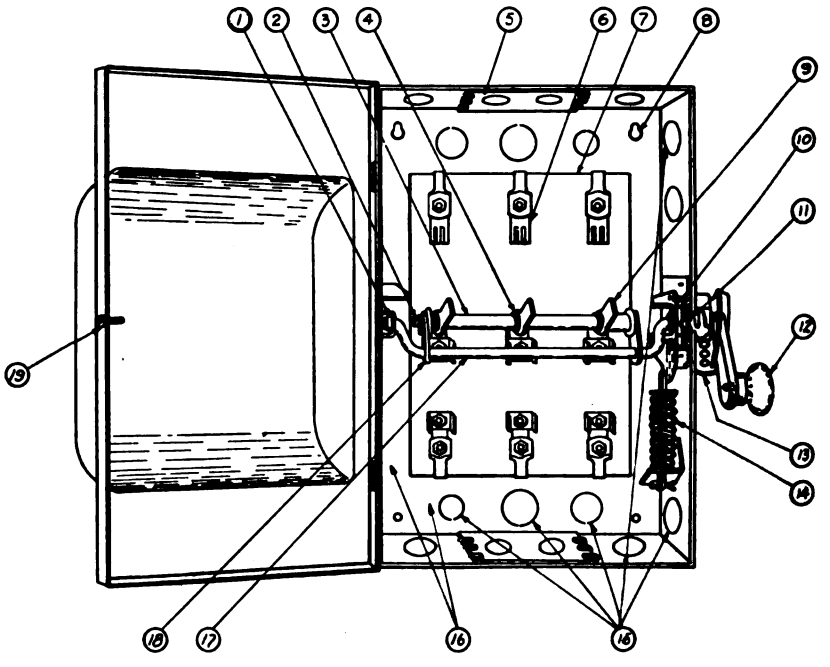
But in the case of protection for the authorized maintenance man, it is necessary to consider the conditions surrounding his work as similar to those of a fireman. His job calls for the location and correction of troubles and he is required to approach and handle circuits where hazards to life may lurk in unexpected places. A measure of protection is, therefore, essential against inexperience, carelessness, lack of observation, oversight, haste and the like in doing his work.

In large industrial works where the maintenance department is made up of experienced electrical men, the requirements of protection for these men are less rigid than in those plants where a part of the repair and maintenance work is done by the operators of the switch, so that the measure of protection that is essential in all cases should take into consideration the possible handling of switches by those not familiar with the hazards of live electric circuits.

Accidents and injuries can be traced to a variety of causes. The accompanying analysis of 1,214 minor accidents and 724 disability accidents, causing 6,867 days' lost time, shows typical causes and the relative importance of each with the corresponding time lost during a period of seventeen months.

Analysis of Accidents and Time Lost In One Organization During a Period of 17 Months

Causes of Accidents	Minor Accidents Per Cent of Total	Disability Accidents Per Cent of Total	Days Lost Per Cent of Total
Poor judgment	29.2	31.8	30.9
Contributory negligence of others	12.8	11.5	14.4
Haste	6.6	10.1	8.9
Mechanical manner of doing work (Lack of concentration)	13.4	9.8	8.4
Method pursued not suitable for work	5.2	5.7	7.6
Rules or instructions not observed	3.4	6.1	6.0
Lack of proper inspection and maintenance (Defective tools, materials and devices)	6.4	6.5	5.4
Conditions beyond control (a) Elements (b) Non-Industrial	17.8	8.4	5.1
Lack of proper instruction	1.7	1.7	4.3
Physical condition of injured	1.2	3.7	2.8
Protective devices not provided	.5	1.1	2.4
Protective devices not used	1.2	1.7	2.4
Improper tool or device	1.2	1.2	.8
Willfulness	.1	.4	.4
Class of work beyond physical or mental ability of injured	.2	.4	.2
Intemperance	....	....	....
	100.0	100.0	100.00
Total number in 17 months	1214	724	6867



Construction details of the safety switch manufactured by Mutual Electric & Machine Company, Detroit, Mich.

These numbers refer to the drawing: 1. Drawn bearing. 2. Steel cross bar. 3. One piece horn fibre insulation. 4. Double insulation on cross bar "cold flowed" into the blade. 5. Removable end plate (interchangeable). 6. Break jaws and fuse jaws type "A" parts (not punched type). 7. Slate base. 8. Button hole for convenient mounting of cabinet. 9. Switch blade reversible; if damaged in service, turn it over. 10. Drop forged hub on which the interlocking mechanism operates. 11. Entire mechanism removable as a single unit, easily replaced. 12. Insulated knob handle. 13. Provisions for locking the switch in various positions, using one, two or three padlocks. 14. Quick-make and quick-break spring (switch will work with spring removed). 15. Standard knock-outs located in both sides, top, bottom and back of the box. 16. Ample wiring space along the sides and ends. 17. Steel operating lever. 18. Links which connect the operating lever to the cross bar. 19. Cover catch interlocking screw.

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Main Elements of a Complete Electric Circuit in an Industrial Works

1—**Main bus of plant switchboard or substation.**
The circuit feeding this bus is provided with protection in the station design, from the standpoints of safety and continuity of service.

2—**Panel controlling the feeder leaving the main bus.**
This circuit is also a part of the plant design from an electrical viewpoint and usually carries full protection for safety and continuity of service.

3—**Feeder cable and wiring.**
This part of the circuit is insulated for the voltage it carries and designed for load handled.

4—**Disconnecting devices.**
These devices are installed to cut out the apparatus connected to the main feeder for inspection and repair and may be provided with or without overload and other protection.

5—**Protection for the apparatus operated.**
This includes overload, voltage and phase protection with the necessary starting and control mechanism.

6—**The apparatus that is operated from the circuit.**

However, electrical hazards are by no means the largest causes of injuries to those who handle electrical circuits. One authority who has made a study of accidents reports that nine per cent of the total accidents reported were due to electrical shock, but in this connection the seriousness of this hazard is shown by an analysis which revealed that this nine per cent of all accidents was responsible for 72 per cent of the total cost of accidents, 75 per cent of the fatalities and 78 per cent of the lost time. Adequate protection of those whose job it is to work on electric circuits and who are authorized to do so is, therefore, imperative both from a humanitarian standpoint and from the standpoint of savings in dollars and cents.

It is not proposed in this article to lay down a cure-all for accidents on electric circuits nor to attempt to show how one type of so-called safety switch provides such protection better than another. On the other hand it is proposed, first, to bring together the ideas of users of these devices to show the ways they are approaching the problem of protection through the use of switches that possess safety features and the requirements in operating and service conditions surrounding this work and, second, to show how the manufacturers of switches that possess safety features are trying to meet these requirements in their switches.

As a starting point it is important to get a correct picture of the main elements of a complete electric circuit in an industrial works and the parts of this circuit where protection through a switch that possesses safety features is essential from one or more of the four phases of protection mentioned above. These main elements of the electric circuit in every industrial plant of considerable size are given elsewhere.

The types of switches that are used between the feeder and the machine operated and provide protection from the four standpoints already outlined: namely, to the worker, to the maintenance man, to the machine and against fires, are sold under the names "safety switches" and "across-the-line-starters." From the standpoint of their use in industrial work a good but rough subdivision in the following groups was made by P. T. Vanderwaart, Electrical Engineer of the New Jersey Zinc Company in a recent paper presented before the Association of Iron and Steel Electrical Engineers. This subdivision into groups is based upon whether or not the switches perform one or more of the following functions:

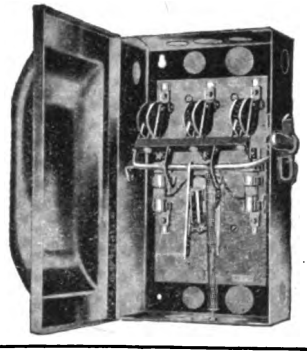
A—Plain disconnection.

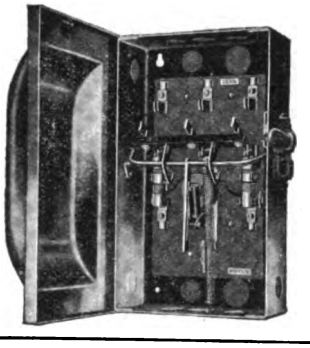
B—Disconnection plus overload protection. When considering a piece of apparatus which aims to combine the plain disconnect function with some other function, the device should not be so elaborate as to require a separate disconnect ahead of it.

C—Separately-mounted overload protection.

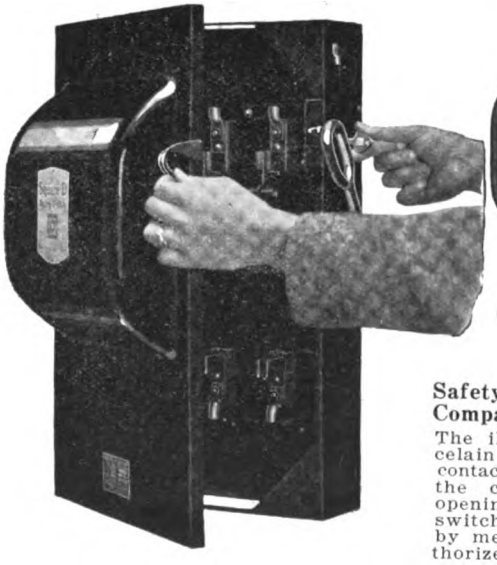
D—Plain starter or controller—including push-button-controlled "across-the-line" starters.

E—Starter and controller with automatic overload protection. These usually have overload protection in but two of three phases. They are recognized by the National Electrical Code as sufficient under competent supervision but do not protect against coincident grounds unless the unprotected wire is the grounded side of an





Motor starting switches with overload relay and under-voltage release coil to protect against single-phase operation. Made by Trumbull Electric Mfg. Company, Plainville, Conn.

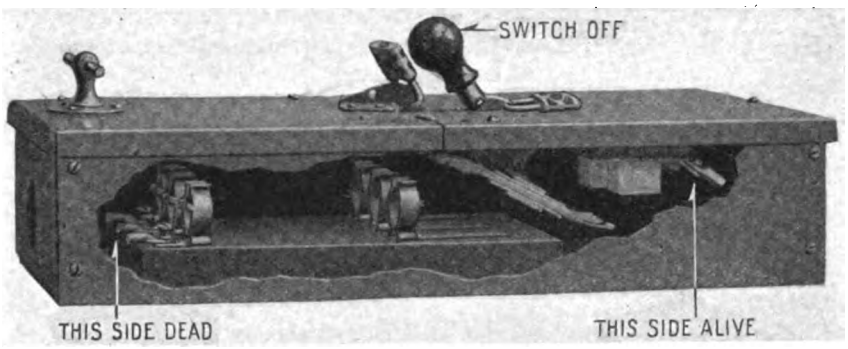


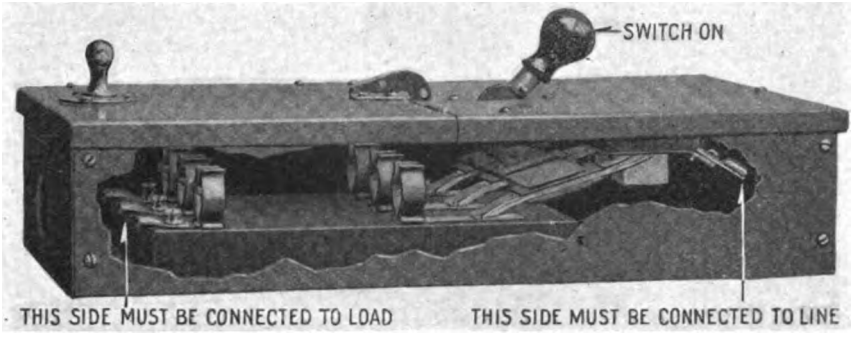


Safety Switch Made by Square D Company, Detroit, Mich.

The illustration above shows porcelain cover protection for switch contacts. At the left is illustrated the construction which prevents opening the switch cover while the switch is in the on position except by means of a key carried by authorized persons.

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Enclosed auto-lock brush type of safety switch.

These switches are designed for industrial circuits of 250 volts a. c. or d. c. and 600 volts a. c. in ratings of 30 to 1,000 amp., with and without fuses. When the cover is opened it is impossible to touch live parts. When contacts are closed the cover cannot be opened. Made by The Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

intentionally grounded circuit or otherwise made the same wire on all services.

Mr. Vanderwaart in his paper gave the following as essential points to consider in the operation and construction of the above groups of switches that possess protection features.

1—Are all live parts enclosed?
This protects the ordinary worker from coming into contact, but increases the hazard to the operator.

2—Is it externally operated?
This safeguards the operator.

3—Is it possible to so connect it that safety features are inoperative?
This is not objectionable if action is taken to prevent accidents due to violation of instructions, careless work and lack of education.

4—Suitable for location?
Is cast iron better than steel for the enclosing case?

5—Are all parts strong and compact without requiring excessive space?
Note desirability of having 200- to 600-amp. fused knife switches in 500-volt a. c. pole spacings instead of using the much wider 600-volt switch for 400-volt circuits.

6—Is it tamper-proof?
Comment on oil-immersed switch: If parts are out of sight under oil, it is a lot easier to resist the temptation to monkey with the adjustments to keep going under certain circuit troubles instead of running down the particular trouble.

7—Can unit or parts be quickly removed, replaced and repaired?

8—Ample wiring space?

9—Facility of arranging for conduit or open wiring connections?
Suggest stocking blank end plates which can be easily and quickly drilled in the field for most desirable conduit location or for porcelain bushings of any size. Eliminates expense of stocking several items and the requisitioning of particular ones suited for each job with the chance that the electrician finds some other type would better suit when he makes the installation.

10—Is provision made for easily connecting test instruments into the circuit?
Desirable where periodic motor load tests are made.

11—Is contact resistance liable to become excessive?

12—Can switch be locked in "off" position?
Necessary to protect electricians working on the circuit or appliance or men working on the driven apparatus.

13—Is it possible to open door with switch closed?
It should not be possible to do so if the operator is to be protected when replacing fuses. Same applies to items 14 and 15.

14—Is it possible to close switch with door open?

15—Is it possible to touch live terminals with door open?

16—Is it possible for authorized inspector, and he only, to inspect live parts without interrupting service?
This feature can be had and is sometimes desirable where it is important to keep the appliance energized continuously.

17—Is accidental closing of switch probable or possible?

18—Can disconnect be opened manually under extreme overload?
This sometimes has to be done and the success of the operation depends upon speed of break, barriers, etc.

19—Positive make on closing?
This means are you sure that the switch will be 100 per cent closed?

20—Quick make?
This is action similar to quick break, and is sometimes desirable.

21—Rupturing capacity.
When located close to large capacity sub-stations, this feature should always be checked up. It is here that some other type of overload protection than plain fuses must be considered.

22—Characteristics of overload device?
Effect of zero weather. Adjustable settings for time limit and minimum current to trip. Time-current characteristic. (Remember the cumulative effect of "creeping." That is, if the relay has started due to the action of a high current and the current decreases to a lower value, the remaining time to trip may be very much less than if the relay had started initially under the lower value of current.) Permissible deviation. Non-automatic reset with U. V. release. Comment: Volt. amp., watts, temp. rise. (Well to have.)

23—Is operation of double-throw motor starter positive?

24—Does switch provide undervoltage protection, and can it be arranged for undervoltage release if desired?

25—Characteristics of operating coil in electrically operated starters?
Volt., amp., watts, temp. rise., (Desirable to have this information.)

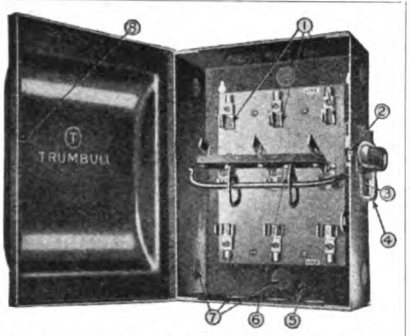


Externally operated fused switch designed for industrial circuits and as a meter service switch.

The construction is shown at the right. The switch and box are standard with or without meter. made by the Palmer Electric & Manufacturing Company, Cambridge Mass.



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Construction of safety switch made by the Trumbull Electric Mfg. Company, Plainville, Conn.

1. Built-up contact jaws. 2. Safety catch. 3. Hinge rivet is upset and can not loosen. 4. Can be locked open. 5. Ample room for running wires. 6. Quick break. 7. Knock-out—ends, sides and rear. 8. Pin with which catch operates.

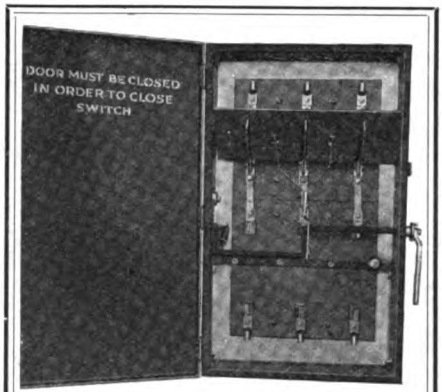
In view of the fact that the Association of Iron and Steel Electrical Engineers has devoted considerable attention to the use of so-called safety switches and that the Pennsylvania State Department of Labor and Industry has required certain protective features on such switches since July 1, 1917, abstracts are presented in what follows of comments by members of that association in its discussion on the subject. These comments reflect experiences with switch protection and the requirements of service in connection with different mill operations and processes.

The service conditions in the state of Pennsylvania are similar to those of other states and are well summarized in the following comment before the Association of Iron and Steel Electrical Engineers by Morton G. Lloyd, Electrical Engineer and Chief of Safety Section, Bureau of Standards, Washington, D. C.:

I think the statement made by one of the speakers could be accepted by all of us: that the manufacturer can give us what is required to do the work if we know what we want and are willing to pay the price. To me, the principal question in connection with this subject is to determine just what we do want; what is really needed as to the type of enclosed switch under the different circumstances where one is to be used. We have available now almost everything from the mere enclosure for the switch up through the range that was described in the paper this evening to a type that is substantially fool proof—that is, one where it is almost impossible under any circumstances to come in contact with a live part and which it isn't easy to wrongly connect.

Under given circumstances of use, which one of the various types should be selected? Assuming that you use an enclosed switch for the protection of persons from accident, the question is then, how far is it worth while to go in trying to protect those who may use the switch from accident, that is to say, from shock or contact with live parts?

The mere enclosure of the switch, as was said in the paper, is sufficient to protect anyone except the user of the switch. In most installations we have combined with the switch the element of protection to the circuit from overload — that is, either a circuit-breaker will be used or a switch will be installed with fuses. If fuses are to be renewed when they blow by the man who is working on the job, it is usually considered desirable that those fuses should be killed before they are handled. To accomplish that purpose



Enclosed externally operated switch with box made in two parts.

This construction makes it easy to remove the sides and ends and facilitates wiring. Made by the Wayman Electric & Manufacturing Company, East Palestine, Ohio.

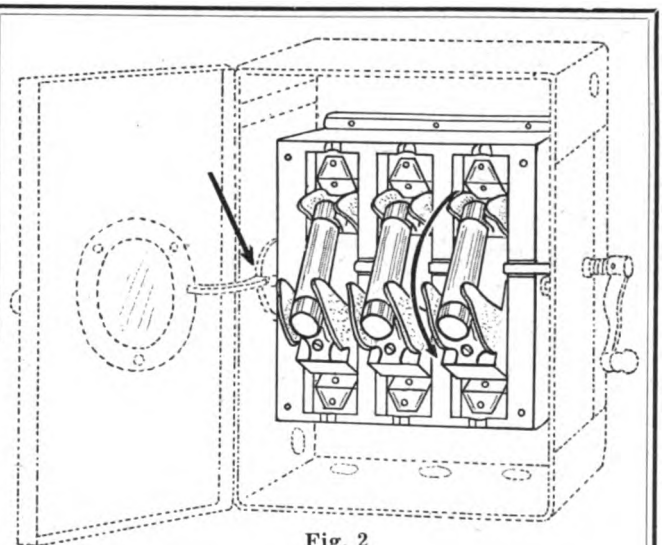


Fig. 2

Dead-front switch with all conducting parts including fuses encased in insulation.

The fuses are automatically thrown into and out of circuit with the throw-off handle. Fig. 1 shows switch on and cover open with no exposed live parts. Fig. 2 shows switch in process of being turned to off position. Fig. 3 shows switch in off position with fuses in position for changing. Switch cannot be operated when the door is open but door may be opened safely when switch is either off or on. Made by the Super-Safety Electric Switch Company, Chicago, Ill.

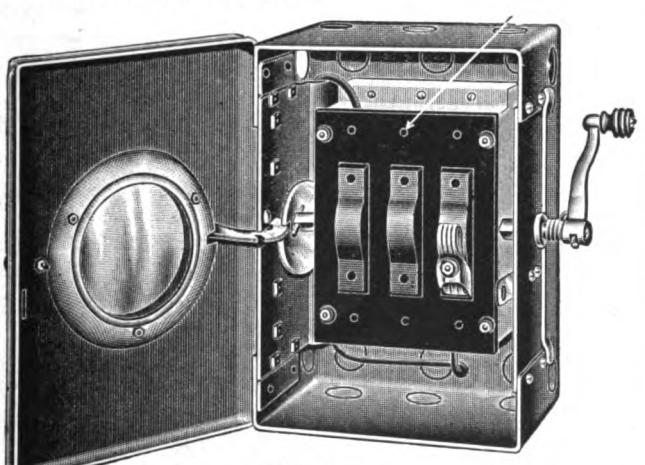


Fig. 1

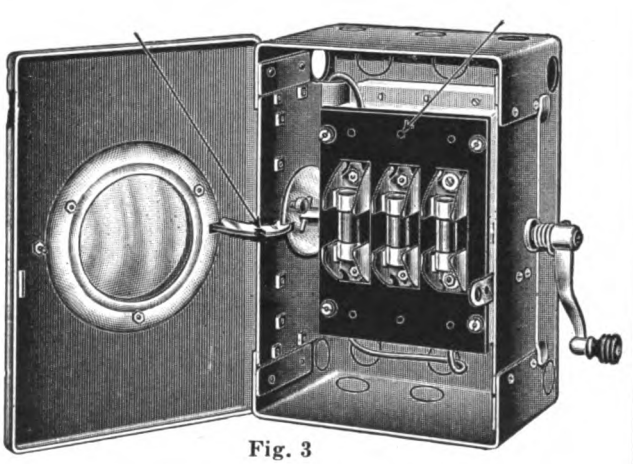
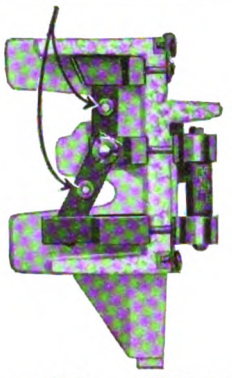


Fig. 3

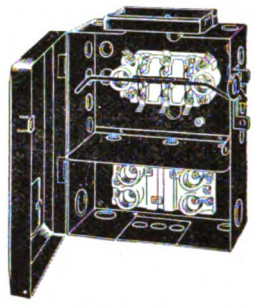
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Cross-section through porcelain switchblock showing off (at left), start and run positions of switch.



This construction is used in switches made by the Union Electric Mfg. Company, Milwaukee.

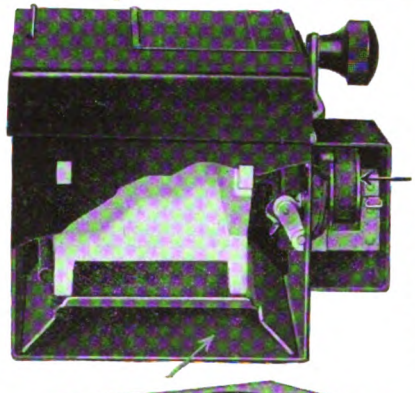


Safety switch made by the Aurora Steel Products Company, Aurora, Illinois.

one of the types of safety switches that we have on the market is a type with an interlock between the switch handle and the cover of the enclosure, so that the fuse is not accessible until the switch has been opened. That then renders the fuses dead before they are actually taken out for renewal, and that protects from shock a person who has to renew the fuses. However, in a good many types of switches that also renders it impossible to see the switch or inspect it in actual service, because to open the case to see it you have to first open the switch.

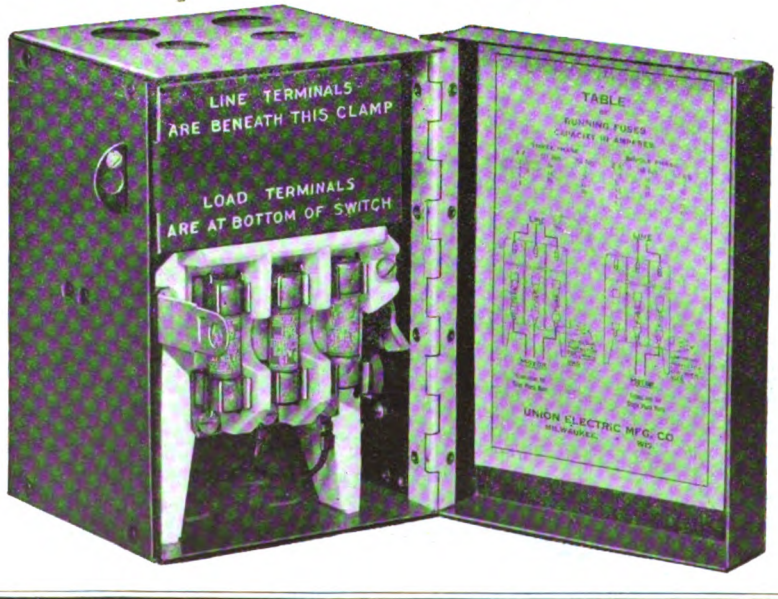
One complaint that we hear from a good many of you operating men is that that is not a satisfactory condition; that you want to be able to inspect the switch with the circuit closed; and to meet that we find that a number of manufacturers have brought out types that will accomplish that. One method of doing so is to have two compartments—one for the switch and one for the fuse and to interlock the fuse compartment, and to put a permanent lock on the switch compartment, so that it is only accessible to the man who has a key to that lock. He will usually be the plant electrician who is supposed to know enough about his work to safely open the switch compartment with the switch closed.

Here in Pennsylvania, your State Department of Labor and Industry has adopted some rules covering electric equipment in factories, and among their rules is one which requires the interlocking type of fuse switch on at least circuits of higher voltage, such as a 440-volt motor circuit. It is a question whether that much protection is really needed. It is another equally important question whether that same protection should be required on 110-volt circuits; the answer to this question so far has been very largely a matter of opinion. I do not think we really have enough data as to actual experience to finally determine the answer to either one of these questions and those who are interested in this subject and are concerned with the making of rules that must be followed by industrial plants are very anxious to get the information and the data from experience that will give a final answer to these questions.



Section showing low-voltage release coil and bottom space for wiring provided in switches made by the Union Electric Mfg. Company, Milwaukee, Wis.

When the door of the switch below is open the fuses and all current-carrying parts are dead. The switch cannot be opened with the door open and the door cannot be opened when switch is in start or run positions.



In the January, 1923, issue of INDUSTRIAL ENGINEER the following request for information from a reader was published:

WHAT MAKES A SAFETY SWITCH SAFE?—When installing safety switches the user has in mind protection from fire and safety hazards. I would like to see published in INDUSTRIAL ENGINEER comments from both users and manufacturers of safety switches on what they consider the essential points in the construction and use of the enclosed type safety switch.
Detroit, Mich. J. H. R.

The letters that have been received from readers in answer to the questions outlined are presented on pages 395 to 398. In the meantime, letters were addressed to the manufacturers of safety switches requesting that they outline what they consider *the ten essential points of safety switch construction* to meet the requirements of protection needed in industrial electrical circuits. The answers from manufacturers are presented on pages 398 to 401.

These comments show that manufacturers are studying the protection requirements of industrial service and that standards of construction are being established as the requirements of users and their service conditions are made known. Other details of developments as they come to light, will be presented from time to time in INDUSTRIAL ENGINEER.

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What the User Expects of a Safety Switch

From the standpoint of its protection for workers, maintenance men, machines and against fires and its ability to handle service requirements in operation

P. T. Vanderwaart, Electrical Engineer, The New Jersey Zinc Company, Palmerton, Pa.: In what follows I am mentioning some of the most important factors which should be considered in safety switch construction.

1—Heavy welded sheet steel or cast iron enclosing case having a well-fitted door with provision for external operation of switch and with provision for locking the switch in the open position.

2—High mechanical and electrical factors of safety.

3—Provision for subconscious inspection that fuses are positively disconnected before replacing them. This is probably best accomplished by having the open switch blades visible to the operator when replacing fuses.

4—Provision for inspection under load by an authorized inspector and he only.

5—Interlock to prevent opening the fuse enclosure when the switch is closed and to prevent closing the switch when the fuse enclosure is opened.

6—Dust proof and sufficiently moisture proof to prevent rusting of parts which are not ordinarily protected by paint. This will require the use of brass bolts and nuts for switch parts.

7—Provision for quick repair of switch parts without demounting the enclosing case or disconnecting conduits.

8—Positive make and quick break with necessary accessories to give the switch a rupturing capacity of at least ten times rating for 30-amp. and 60-amp. switches decreasing to at least two times rating for 800-amp. switches. Switches to be marked with the current which they can safely interrupt.

9—Assurance of sufficient contact surface and pressure to prevent heating after a reasonable amount of operation and burning of the switch blades and clips.

10—The designs should be such that all the good results of "quantity production" can be realized, enabling the switch to be put on the market at a price which the customer can afford to pay. A price of from 15 cents to 25 cents per ampere of rating respectively for large and small switches should bring in the business.

G. H. McKelway, Westfield, N. J.: Of the two kinds of danger which it is attempted to avoid by the use of safety switches, the danger from fire is much less important than the danger of injury to persons operating or maintaining the switch.

The arc drawn when operating the ordinary type of knife switch on all ordinary loads is very small and seldom amounts to very much even on heavy overloads, which would be expected to open the circuit breaker or blow the fuses protecting the circuit. Therefore, unless the switch has been placed very close to inflammable material or where there are gases that might be ignited when the switch is opened, the danger from fire should be almost negligible. The enclosing of the fuses in the same covering that protects the switch may add slightly to the safety from fire but, if cartridge fuses are used there is but little danger of the fibre casing surrounding the fusible element being destroyed except on a dead short circuit with plenty of station capacity behind it.

So far as protection to persons is concerned, there should be no opportunity for anyone, at any time, being able to come into contact with any live parts. The fuses should be installed on that side of the switch where they will be dead when the switch is open and the construction of the enclosing box should be such that the compartment in which the fuses are installed cannot be opened while the switch is closed. The blades should also be dead when the switch is open so that any repairs to them can be made with safety and while working upon them it should be impossible for the repairman to make contact with the jaws, which should be the only parts alive at all times.

There should be provided a means of locking the switch in the open position so that it can not be closed by mistake while anyone is working on the circuit controlled by it or on any machines operated by motors receiving their current through that circuit.

Ralph H. Hoyt, Detroit, Mich.: The present tendency in making a switch installation is to make it not only safe from fire hazard, safe from persons tampering with the installation, other than those authorized to do so, but also to make it safe for the persons who operate it. For these reasons the manufacturers have developed lines of safety switches to meet this demand which can be classified as follows:

1—Switches operated externally with no safety feature other than the inclosure.

2—Switches operated externally but only accessible with the switch in the open position and to those who are in charge.

3—Fused switches, the fuse compartment being so interlocked with the switch that the fuses are accessible only with the switch in the open position.

In making an installation it is necessary to choose the right type of switch for its purpose, without incurring unnecessary expense, and still secure the safety features of the switch. The first class of switches might be considered as a disconnecting switch, where the duty is not heavy, where a maximum of over 110 volts per pole is not exceeded, and only accessible to authorized persons. Class number two should be used as a disconnecting switch where there is a heavy load, where there is over a difference of potential of 220 volts per pole and for fused disconnecting switches where a maximum of over 250 volts per pole is exceeded and not over 150 volts to ground. Class number three should be applied to all ungrounded alternating current systems, as a switch feeding from a high tension line and also used ahead of other control apparatus.

With the advent of the safety type of switch, it was at first thought that all that was required was to place a switch in a box and enclose it, without much thought as to how this would affect the operation or life of the switch. This inclosure led to many difficulties, such as the operator in throwing the switch could not tell whether it was way in or way out as the case might be. Due to excess arcing because of this, the contacts soon became pitted and the switch had to be discarded; by reason of the fact that little thought was given to the size of box necessary to dissipate the heat when the switch was pulled under load, it became badly burned and from frequent operation soon gave out. Because of frequent renewals from the above causes it not only made a costly installation, but also a hazardous one as well, as it was often necessary to make a replacement when the line was hot, or else close down the line which it controlled.

Due to the failure of these switches, cost of maintenance and frequent renewals, questions arose as to the advisability of installing them. The manufacturer, because of the complaints entered, soon began to make a scientific study of the requirements necessary, which has resulted in the present lines of safety switches, which have positive operation, simplicity of parts, and ruggedness of construction.

For satisfactory results a large amount of space is necessary especially near the points where the current is interrupted, so that the arc will not be confined but have plenty of room to become dissipated. In general the distance to ground should be equal to the distance between poles. On switches of 500 volts or over and in case of fused

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switches, barriers are provided between poles. On medium and large capacity switches special arc-quenching barriers are provided.

Because of the fact that switches became burned, caused by the speed with which they were operated, a spring or toggle arrangement was resorted to whereby the switch has a quick make and a quick break. With the development of the first of these switches many faults arose. It was found that due to the impact of the quick make and break arrangement the parts would soon become loose and fall apart. To overcome this, much heavier parts were used with special riveting and fastening, with a much more rugged switch as the result.

The safety switch has many applications, one of which is motor starting. In this field the switch meets its real test. The design has to be such as to take care of the initial rush as well as the normal current so that there will not be excess heating or burning of the contacts. With the older types of switches used in this connection, it was quite common practice to supply oversized fuses to take care of the initial rush of current. This created a very undesirable feature in that the line was not properly fused. Now there are on the market time element devices or thermal fuses which take care of the momentary peak loads, and still have the correct size of fuse.

The location of a switch has an important part in the construction of it. A switch mounted in a damp place, or a place that is subject to sudden changes of temperature, needs special attention as to sealing, otherwise the switch becomes corroded and may fail without any apparent reason.

It is to be remembered that no matter what the construction of the safety switch may be, if an incorrect application is made, the safety features of the switch may be entirely destroyed.

***H. Hollis, Superintendent, Electrical Department, Bethlehem Steel Company, Lebanon, Pa.:** I have always been of the opinion that the development of the safety switch was brought about more with the idea of protecting the man who has to operate the switch rather than the electricians who are supposed to be more or less trained men on the job and can reasonably be expected to take the necessary precautions to protect themselves. I sometimes think that, as the development of the safety switch has only extended back a matter of four or five years, that we sometimes expect too much from a new piece of apparatus. Some of you will remember the early development of the oil switch —one point brought out by a speaker was that a man was shocked by one of the blades of the safety switch that was supposed to be open remaining in. I had an experience personally with a 2,200-volt oil switch, which was composed of two double pole elements, operated by a common lever. This switch was on a 150-hp. motor. The fuses blew and I attempted to renew them. I saw the switch handle was open and had renewed one fuse, but when I put the remaining fuse in I had a 2,200-volt short circuit. From that experience I think we ought to give the manufacturer a little more time to make a perfect product. It is something that has to be worked out as we have to use them, the Pennsylvania State Electric Code adopted in July, 1917, making this compulsory. I think it is up to us to be a little more patient with the manufacturers and co-operate as much as possible with them in giving them suggestions due to our experience with failure of operation, to help make the safety switch a perfect product.

***J. R. Bower, Assistant Master Mechanic, American Car & Foundry Company, Berwick, Pa.:** We have not had any serious trouble with the safety switches, either due to accident to the men, break-downs or burning of the switches, although I find that these are frequent complaints from various plant engineers. I believe that our success along this line is due to two reasons—first, I believe that we are using one of the best safety switches on the market today; second, we do not exceed 250 volts in our plant. I believe that a great many of the men who are making complaints due to flash-over and burn-outs are using from 440 to 550 volts. However, with the little trouble we are having with the safety switch, I am not satisfied with the greater majority of them due to the fact that they have fuse protection. If we go back a few years we will recall the time when we used an open lead wire for a fuse on an open switch. A little later the enclosed cartridge fuse was introduced, and still a little later came the re-fillable fuses, which at the present time are made by numerous manufacturers, and there are several good ones on the market today. The trouble we are now encountering is the constant blowing-out of fuses, over-loading of same, refills, new fuses, fuses getting lost or burning to such a point that they are not usable, which is making an exceptional high maintenance cost to which there seems to be no end. Now that there are safety switches on the market, using circuit breakers and magnetic relays or contactors, that are worked out to such a high degree of engineering, and the cost coming to a point where they are not prohibitive, I believe that the day of the fuse is passing, to be replaced by these enclosed circuit breakers and magnetic relays or contactors.

***A. J. Standing, Superintendent Electrical Department, Bethlehem Steel Company, Saucon Plant, Bethlehem, Pa.:** Granting first the premise that we are interested in the safety of our employees primarily from a humanitarian standpoint, and, secondly, from the standpoint of compensation cost, the fact then comes up that the Safety Welfare statistics show I think that about 80 per cent of the accidents in industry are attributed to carelessness and ignorance, and the remaining 20 per cent are therefore attributable to lack of safeguards and safety protection. The other question that comes up, is protection for a skilled man, and protection for a non-skilled man.

In other words, where are we going to draw the line of demarcation between switches which should be converted to safety switches and switches which are normally safe as knife switches? By that I mean, take your power house station, your control pulpits, in locations which are accessible primarily to the men of your electric department whom we assume in that respect at least are trained men as compared to the average run of plant labor. Assuming, therefore, that the switches that we are most interested in are those switches in and about your general plant with which the unskilled and common labor comes in contact, that as a starting point simplifies our problem and gives us a cheaper point from which to start. It also means this: that you see today switches running up to 100 amp., 200 amp., of the type used in steel mills, that is practically where we start. If we take our standard steel mill construction as applied to an average table motor of 75 to 100 hp., you are going to have a tremendous number of very high priced switches which, in turn, will take up a large space.

I think, therefore, the point of attack on this subject is first, to take care of those isolated lighting switches, and units of that kind, which are scattered broadcast over your plant, can be readily mounted from a cost standpoint and will accomplish the greatest good from a safety standpoint, taking into consideration your untrained men. We consider the safety switch as a unit as we see it today. Our requirements are somewhat contradictory. We want a switch which has adequate spacing to handle the voltage and current demanded of it, and yet, at the same time we want that switch small enough to be readily mountable in places which we have provided to mount switches in. In other words, you can not have a switch of such size that it is going to be interfered with by passing objects—ingots and boxes and stuff like that; another thing is, we want the switch rigid and strong and unbreakable, because the switches are operated by sticks and poles by anybody going by in a car; and at the same time we want the switch reasonably cheap.

These four extremes in the manufacture constitute rather a hard problem. The manufacturer has got to lead us somewhere in that region with a switch which will do our work as far as current and voltage

*These comments were presented at a recent meeting of the Association of Iron & Steel Electrical Engineers during a discussion of safety switches.

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is concerned, and yet will not place an undue cost on our product. There is no question in my mind but what the trend is coming toward safety switches, but the more or less sudden upstart of the safety idea which has resulted under the severe Compensation Laws, has brought about a complexity of switches, and it is questionable whether some of them have involved very many safety features. Now, today, in analyzing these switches as we see them, there unquestionably has been a marked improvement, but it is a question whether there isn't a great deal of room for improvement. I think one speaker mentioned the quality and strength of the enclosing boxes. Practically every box today seems to be rather light. Another point is from the standpoint of the electrician working inside those boxes. If he has any live connections to make he is in danger of grounding his pliers and getting a burn himself. Another point is that when the switch is enclosed it has to be dust proof and moisture proof; at the same time you have got to ventilate your switch box so you do not have dangerous gas collections and explosions. These are just a few points, but it means that we have got to start at the thing from a safe and sane standpoint and not rush into it simply to save ourselves a little compensation cost.

***H. S. Boone, Plant Engineer, Shoemaker-Satterthwaite Bridge Company, Pottstown, Pa.:** A great deal seems to have been said about the enclosing of switches to make them safety switches, and a great deal has been brought out about the ability of the switch to break the circuit; but I have not heard anything about the ability to make a circuit complete. I think it is just as important to have a switch that will necessarily get contact when it is put on. These switches are usually boxed up so that the operator can not see them, and if a switch only touches on the contacts he is certainly going to have heat if it carries any kind of a load. I think that is a point that should be brought out in all the switches.

***H. W. Moser, Electrical Engineer, The Ballinger Company, Philadelphia, Pa.:** In laying out our equipment in buildings, we try to get an equipment that will be safe for those who have to operate it and be around it. I have in mind particularly a condition that existed in a factory where we changed over some equipment. They had some 550-volt equipment, and on some of the motors they simply placed the open switches about four to six feet high on the walls, and then they passed their trucks along there. Just before we went into that factory they had bumped against one with an iron truck; the result was a small fire; then they wondered why the switch was not satisfactory. We changed that over for them, and after changing it over they had practically no trouble. We also changed a number of switches of a similar character, and by so doing we eliminated one of their greatest troubles: namely, the shockings, not always very serious but at least not very pleasant, of both male and female workers. I cannot say much about the large switches, because we do not use many of them. But the smaller switches we found very successful in that line of work. As to price we have found the same thing—to get a switch that is really good the price goes up so high that very often it is practically prohibitive and we cannot use it.

***Mark R. Woodward, Assistant Chief Engineer, Lehigh Portland Cement Company, Allentown, Pa.:** We have had a little experience with safety switches but have not paid much attention to the question of buying a switch that would be as cheap as the old style knife switch as our primary object has been to protect the workmen.

We have taken the attitude that when you call in the doctor you do not have to protect him against contagion, and skilled electricians will look after their own safety, keeping each piece of electrical apparatus in such condition that the ordinary workman is protected.

With that end in view some years ago we bought the best switch that we could find and after trying it out, discovered that it had mechanical details that were not entirely satisfactory. Then another switch came on the market which we thought would overcome these troubles. It was certainly made so well mechanically, and electrically, that it looked as if it was about right. These new switches worked fine and we thought we had solved our problem, until one day, someone tried to open one in order to disconnect a motor. The controller of this motor was out of order and it could not be shut down except with the load on it. No doubt many of you here have had the same experience and know what happened to the switch. That was an expensive switch; it was a relatively expensive one when we bought it and was more expensive from the results we got when we tried to open it.

Then we began searching for a switch which would be safe for our workmen, even if it must be opened under load, and located one which promised this kind of protection. We put in a few such switches, which proved satisfactory in test, and hope that our trouble may be overcome. We find that each time we change to a new type switch the new one we buy is more expensive than the one we were using.

I am heartily in accord with what a previous speaker said: that we need a safety switch that will be safe for the man who is to operate it, and which will permit him to use it for the purpose for which it is intended: namely, to disconnect his line, and in case of emergency to use the switch to break the circuit even though there is a load in the circuit. We think we have a switch now that will do that and so far the experience we have had with it is satisfactory. But, as with previous switches that we also thought were good, only time and a thorough trial under the adverse conditions of dust and dirt and emergency operation will tell whether or not that problem has been overcome.

***H. Cosdon, Electrical Engineer, Midvale Steel & Ordnance Co., Nicetown Plant, Philadelphia, Pa.:** I feel that we want an enclosed switch that the operator cannot get into while the switch is in the "In" position, but is accessible to the repairman to see if the switch is all right without any disturbance of service. There is another feature we desire; in case of trouble in the switch where the repairman may have to disconnect the live lines and take the switch down for repairs the enclosure should be removable around the live parts. This is one of the bad features with most safety switches today—he cannot do it with safety. It looks as though the manufacturers are working toward protecting the repairman; and if this can be done on small switches as well as on large ones, I think a satisfactory switch will be produced for steel mill use.

***George W. Richardson, Electrical Engineer, American Bridge Company, Pencoyd, Pa.:** Our main trouble with safety switches has been perhaps a bolt or screw would be pulled out leaving one blade in, as they are only held in place by one screw or one bolt. I think if they would built them to have two bolts or screws two would not break as easily as one; we find they break. They do not look like they were going to break but after they get in service awhile, with everybody handling them the way they do, we find they break—not only break screws, but the angles on them. We have had two accidents relative to a man getting shocked by angle or bolts breaking off and allowing one blade to stick in. He thought the switch was open. That has been the main trouble. We had one fellow find his switch was not open after he thought it was open, and he opened the door and tried to pull the blade out with his fingers. He burned his fingers. But these accidents will happen. That man, perhaps, was not educated to not touch it, but nevertheless you will find the men that way. I remember a time, myself, and I have been working around the electrical game since 1880, that you will forget once in a while. I have opened the field circuits while holding the ends and I felt it. We will forget once in awhile. I believe the time is coming when we will get a safety switch which will work all the time, and at some nominal price at which we can afford to buy.

***A. H. Allen, Electrical Engineer, Liberty Building, Philadelphia, Pa.:** I feel that the time of knife switches, as a safety switch is past; I do not think connection development is going to increase along this line. I think the safety switch, as I see it, is the magnetic switch in preference

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to any knife type of switch. That suggestion has been brought out by one speaker and appeals to me as along the proper lines. I believe fuses are also undesirable. I cannot see where fuses and the renewing of fuses with the difficulties, which you have and particularly if there are any live contacts or any possibility of live contacts, is a desirable feature, from a safety point of view. If we eliminate the fuses, then we come to some overload protection such as relays; they may be magnetic relays or thermal relays. The question of a magnetic relay at once brings in the question of the time element of that relay and your no-voltage protection. Relays, as a rule, are connected in series with your no-voltage coil, which, in turn, is connected across one of your phases. Your time element, in case the wire is broken on the phase which is not connected up to your no-voltage, gives a time element which is sometimes disastrous from an operating point of view. In other words, you have got to work through your relays before your no-voltage release acts, and sometimes that time element is so excessive as to cause injury to the motor. Another thing, that does not give you phase protection. I am speaking mostly of alternating current, because that is more prevalent than direct current. I think it is very important that a safety first protective device should be of such character as will protect phases as well as overload and no-voltage release. At present, there are comparatively few overload protective devices which give you phase protection as well as overload protection. The question of selection between an electrical overload and a thermal overload is a very interesting proposition and one which, I think, needs a good deal of development and experience to determine which is going to be the most desirable. Personally, it appeals to me that the thermal type is preferable to the electrical type, for the reason that you can generally get a thermal protection on each phase which acts independently; and for that reason it gives protection against single-phase operation.

What the Manufacturer Furnishes as a Safety Switch

And the basis for the design and construction of different makes of switches that provide protection required by users and regulating authorities

Leon H. Frank, Mutual Electric & Machine Company, Detroit, Mich.: Many accidents occur to the practical electrician and maintenance man that are not always due to carelessness but the hazard of his trade. The electrical maintenance man looks on his job in about the same light that the fireman or policeman looks on his job. The fireman considers it his duty to put out fires; the policeman considers it his duty to apprehend the criminal, and the electrical maintenance man considers it his duty to keep the electrical equipment going so as to avoid shutdowns in production or to reduce the time of these shut-downs to a minimum. The electrical maintenance man considers the risk of injury he runs as secondary to the duty he performs and for that reason he often makes temporary connections or bridges around injured apparatus so as to keep the motors running and lights burning until the proper time is found to make the necessary repairs properly and in the manner in which they should be made.

Safety switches which do not take into consideration the fundamental character of the electrical maintenance man's job are, in my opinion, dangerous switches to install.

Considering the question of installation of safety switches, from this point of view, I have outlined below what I consider to be the essential ten points which make enclosed switches really safe:

1—A switch superior in design and workmanship. This requires switches of type "A" or milled and soldered construction. Punched-clip or type "C" parts should not be used in safety switches.

2—Positive quick-make and quick-break construction so that the switch must be in the fully opened or fully closed position and so as to reduce the arc.

3—Interlocks, which prevent access to other than qualified persons.

4—Provisions so that qualified electricians may have access to the switch for inspection in any position.

5—Omission of all features, such as guards or shields which must be removed to allow inspection, and militate against frequent inspection.

6—Ample room within cabinet:
- (a) To permit the proper connecting up of the switch in a minimum of time without damaging the cable insulation.
- (b) To prevent arcing of the switch to the grounded cabinet.
- (c) To allow for the expansion of gases formed by the arc in opening the switch under heavy overloads.
- (d) Working room for maintenance men to make repairs.

7—Removal from the zone of the switch of all loose operating parts such as springs, links, and levers which may get loose and fall into the switch.

8—Most important of all! The blade construction should be of such a design that it is impossible under any condition for any one of the blades to remain in contact when the switch handle indicates that the switch is in the "off" position. Switch blades which depend on clamps, rivets or screws for fastening them to the cross-bar have failed and do fail to come out, and in some instances with extreme danger and serious results. In other words, the switch fails in its chief function—to fully open the circuit.

9—The design of the enclosing cabinet should be of such a nature that on the opening of the door (which should be restricted only to qualified persons) all the operating and current-carrying parts of the switch should be visible so that in the replacing of fuses, etc., to a certain extent, subconscious inspection is possible at that time.

10—The use of springs in switches naturally incurs additional maintenance since springs may be inferior or develop imperfections after a short period of use. The opening and closing of a switch should not be wholly dependent on springs. Springs should only be used to accelerate the action.

H. E. Campbell, Secretary, Union Electric Manufacturing Company, Milwaukee, Wis.: The primary function of a safety switch is to provide a means of switching a motor or circuit on and off which will reduce the fire and accident hazard of such switching to the very minimum. Practically all so-called. safety switches are safe if installed and operated in accordance with the manufacturer's ideas. In practice, however, a safety switch is not safe unless it is practically impossible to install and operate the switch except as intended by the manufacturer. If the safety features can be removed or manipulated without interfering with the operation of the switch, it fails of its purpose. If the safety features cannot be removed or manipulated without rendering the switch inoperative, then it is in fact a safety switch.

G. E. Palmer, President, The Palmer Electric & Manufacturing Company, Cambridge, Mass.: In general any piece of apparatus having such construction details as to effectively prevent contact with current-carrying parts or which shield the operator from the hazards incident to the operation or control of electrical circuits may be properly rated as a safety device. Electrical switching hazards are reduced to a minimum when the switch is surrounded by an effective inclosure and operable without opening the in-

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closure. Where the switch is combined with a fuse, external operation should be provided so as to permit safe switching operations, and the device should be provided with further construction details that permit the fuse being inspected or replaced by the ordinary workman without the exposure of any current-carrying parts with which he may come in contact when in close proximity to the inclosure itself. The inclosure of live terminals in a grounded box increases the hazards to the operator who has occasion to touch these terminals when alive, if he may also come in contact with the box when so doing.

In other words, a safety switch or a safety fused switch can be properly so called only when the device embodies those construction details which provide for the ordinary workman immunity from shock or burn in the performance of any business that he may have with the device.

It is important that the device include construction details that will permit an inspection of the switch and fuse in either the open or closed position, but if this is considered of more importance than the safety of the persons whose business it may be to operate the switch or replace the fuse, and who would not be deemed competent to inspect or repair live contacts in a grounded inclosure, it is fallacious to rate the device as one providing safety to the unqualified operator.

L. L. Brastow, Sales Manager, The Trumbull Electric Mfg. Co., Plainville, Conn.: There are certain fundamental requirements in dealing with safety in switches. I like the expression "Safety in Switches" better than "Safety Switch." The article itself is a safety switch. The cause it serves is safety in switches.

Incidentally this point is missed by a good many who buy and sell and manufacture safety switches. From our standpoint safety in switches begins first with the switch. This is a point overlooked by the great majority of people, I am afraid. So much discussion has been given to the question of box construction and box classification with this or that minor feature placed as a talking point or with a propaganda purpose in the foreground that the main argument in the whole situation is overlooked.

It is switches we are selling and others are buying. It is the switch that does the work. It is the switch that gets the abuse, and that goes wrong when unable to stand the strain put upon it.

In open knife switches it was possible to notice heavy arcing, to notice a loosened screw or wobbly hinge post, or a poor contact, and correct it. But when a switch is in a safety box, locked up and working continually with very little supervision, there is needed in boxes the highest possible type of switch construction, mechanically and electrically super-efficient. A man does not buy a screwdriver because he likes the shape of an insulated handle, but buys it because the metal is strong and will stand the pressure he wishes to give it. It will not twist in the handle. In other words, it is a good screwdriver and does its work. He wants insulation, but is buying a screwdriver.

The safety switch in the earlier days unfortunately got into the box class. Everybody was talking about the handle on the outside. The boxes were more thought about than the switch itself.

It is with this in mind that in our standard boxes for industrial work we have placed a heavily constructed, rigidly built, carefully aligned and assembled switch, machine-made, built-up with contact and hinge jaws sweated and pinned into foot blocks. The Underwriters' specifications call only for such and such sliding and bolted contact area, such and such separation between parts and side of the box, but have nothing whatsoever to say as to the workmanship and the points of refinement which make a switch a real switch. The detailed attention paid to a knife switch, machine-work, alignment and assembling, is the all in all in a switch. This is what makes a difference in price between cheap switches and a good switch.

In considering a safety box, in the first place, it should be something more than externally operated. A safety switch is always externally operated, but an externally operated switch is not necessarily a safety switch. A safety box should in some way be constructed so that it is impossible to open the box when the switch is in running position and not possible to close the switch until the cover is down, although it is very desirable to have the interlocking catch so constructed as to make it possible for an expert to examine the switch under load. There are variously designed boxes presented to the trade. In determining, however, the kind of box that should be used and in building a complete line of safety switches uniform in design and simple in construction, one must be careful not to get into a complicated mechanism, more or less unimportant, that is apt to become inoperative.

It is very desirable to construct a box that can be used for all amperages, say from 30 to 1200 amp., when such larger amperages are needed. There is no objection to putting 30 or 60-amp. or perhaps 100-amp. switches in a certain kind of complicated box which may have unique features that will appeal to a certain number of the trade, which procedure is very likely a good one for the industry because it satisfies certain engineering ideas and finds an echo in certain of those among the trade.

Our position is somewhat different because we are making a complete line covering all types for all possible standard requirements. We sell in every state of the Union as well as abroad. We studied long to get a design of box that would be suitable for all types and sizes of switches, and as above mentioned we make our switch absolutely safe as far as our experience of twenty-three years in switch construction has given us wisdom and we never have known of any accident on any of our switches due to error in design of our box or of our switch construction. We have had faults and troubles but none has been due to the construction of our switches or boxes. They make for absolute safety, but because we, as others, are subject to the human element and an occasional fall down in raw material sent us certain troubles have happened. But, to repeat, never because of fault in design or construction.

Charles A. Robinson, Super-Safety Switch Company, Chicago, Ill.: Herewith are what I consider the ten essential features of a safety switch.

1—Dead front.
2—Automatic disconnection of fuses and contact members from all sources of electrical energy before they can be touched.
3—Complete insulation of all current-carrying parts and their separation by such insulation from the steel cabinet, with consequent impossibility of grounding through the person operating the switch.
4—A design such that the switch proper is safe independently of door or cabinet.
5—Elimination of live fuse terminals.
6—Provision for testing of fuses while the switch is on.
7—Multiple contact with maximum area and self-alignment to secure the full value of contact, with consequent reduction of draw of arc to a minimum.
8—Simultaneous make and break of all poles on both sides so that all phases will be opened simultaneously.
9—Automatic locking of the switch with the door in open position, rendering it necessary that the door be closed before the switch can be operated. Also means by which the switch can be locked in the open position from inside without key but with added security of a padlock on the door.
10—Construction such that back feed into fuses is impossible.

A. P. Ball, Assistant General Manager, Square D Company, Detroit, Mich.: The primary function of an electrical switch is, of course, to serve as a means of completing and interrupting an electrical circuit. An enclosed safety switch, however, has two additional important purposes: First, it must protect from shock, burn, and loss of life. Second, it must protect from fire or loss of property.

The essential points of construction necessary to accomplish the first purpose are as follows: The switch should be completely enclosed in a metal box with provisions for grounding. Should the box by

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any chance become live, it would be dangerous to human contact if it were not grounded. It should be designed to be externally operated. This avoids any possible contact with the live parts within.

The removal of fuses should only be possible when the switch is in the open or off position. The danger from flashes, arcs and accidental contact in removing fuses while the circuit is on, is so great that it should be made impossible.

It should be made possible to lock the switch in either the off or on positions. This avoids the possibility of having the current thrown on and a machine suddenly put into operation when such action might endanger the life of someone or ruin the machine.

The switch box cover should be interlocked so that it cannot be opened when the switch is on nor the switch thrown on when the door is open. This avoids the danger of having inexperienced operators exposed to contact with live parts.

A disabling feature of the interlocking device is desirable so that authorized persons may be enabled to open the cover of the switch while it is on and also to throw the switch on while the cover is open. This enables inspections to be made by those authorized to do such work. This disabling feature can best be accomplished by means of a key, issued only to authorized persons.

Live parts should be covered or hidden even though the cover is open. This may be accomplished by means of insulated hoods over the jaws which allow entrance and egress of the blades through a narrow slit but prevent any accidental contact.

To render protection from fire and property damage, the following points should be observed:

A safe spacing should be maintained between live parts of opposite polarity, and also between live parts and the ground to prevent flashing and arcing.

High-quality insulating material should be used, having a great dielectric strength and low absorption of moisture, in order to keep the current confined within its proper channels.

A rugged mechanical construction is desirable to stand the rough usage encountered in actual service.

A quick make and break feature should be used to insure full contact when the switch is on and instantaneous break when it is thrown off. This is usually effected by means of springs which exert a tension sufficient to move the blades in or out with great speed, regardless of the speed with which the handle is operated.

All springs should be either enclosed in protective housings or so designed that if breakage occurs, they cannot touch live parts and possibly cause a short circuit.

A switch should be completely enclosed so as to confine any possible arcs to the inside of the metal box and so prevent accidental ignition of inflammable material.

By the observance of all these points, the safety switch can eliminate all the dangers of the open knife switch and will increase efficiency in operation and conserve human life and property.

C. J. Zigler, Electrical Engineer, Z & H Mfg. Company, Chicago, Ill.: The question "What makes a safety switch safe?" is answered emphatically and briefly by saying **simplicity.** From the writer's experience along this line, which dates back to the year 1909, we had as our objective in designing our first safety switch the elimination of opening the door to operate the switch, thereby keeping the operator from coming in contact with the current-carrying parts. At that time it was also found that the unusually large cabinets that were used to mount switches in were the most inviting places for the operator to stow away keepsakes which when wanted required the opening of the switch cabinet to get them. In any number of cases this has been responsible for accidents both to the man and to the circuit.

The first requirement, that of operating the switch externally, was made manifest when a simple but rugged operating means was provided with the handle on the outside. Second, the keepsake feature was first overcome by providing a simple means for locking the door when necessity required it and also by the Underwriters' Laboratories Inc. specifying sizes of switch cabinets.

It has long been known that the safety switch when properly constructed is more than just a safety device. It has become an indispensable industrial asset, as many features other than safety are afforded, but to make this statement manifest **simplicity** and **dependable material** must be adhered to.

High initial and maintenance cost are inevitable when complicated mechanisms are employed. And ultimately hazards are added rather than eliminated. Evidently I am of the firm belief that to make a **safety switch safe,** it must be made simple and rugged.

Geo. B. Wadsworth, President, The Wadsworth Electric Mfg. Co., Covington, Ky.: The construction of a safety switch should be such as to completely eliminate the possibility of any form of danger that might occur from the use of such a switch. Our belief is that there are but two vital sources of danger from an electric switch. One is personal injury and the other is fire. So, accordingly, we must arrange fortifications against the possibility of these two items.

To eliminate as far as possible the fire hazard, the switch should be enclosed in a non-combustible enclosure, completely enclosed at all times. Such enclosure would minimize fire hazards. To eliminate personal injury, the enclosure should be so constructed as to completely eliminate the possibility of a person coming in contact with a non-insulated current-carrying part in any normal operation of the switch, with a further provision that would guard against improper assembly of the switch.

After we have accomplished this, together with the conditions above named, we see no reason why such switches should not be classed as a full safety switch.

We do not see any reason why the public should be confused in determining the difference between an enclosed switch and a safety switch. The enclosed switch is not constructed with any exact provision for maintaining the cover closed, or any particular guard against a person handling exposed current-carrying parts while renewing switches, which is an essential operation of any standardized switch, and if the cover is not closed, the fire hazard exists. If a person is exposed to live parts while renewing fuses, the personal injury hazard has not been removed. Accordingly such switches are not entitled to the name **Safety Switches.**

Furthermore, it is our opinion that definite action should be taken on the part of inspection of public safety departments to guard against persons being impressed that such enclosed switches are **safety switches.** The untrained user might be deceived and led to serious injury by the confidence set up by switches bearing the name **Safety Switch.** For instance, the untrained user might deliberately open a case, reach his hands into live wire terminals to insert or extract a fuse and in so doing, come in contact with a part that is charged electrically and receive a very severe personal injury.

L. H. Rosenberg, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.: The hazards from an open switch include the following:

(1) Fire from accidental contact; (2) shock from accidental contact; (3) shock from renewing the fuses; (4) burns from opening a loaded circuit or accidental contact; (5) danger from exploding fuses on high voltage, backed by large power; (6) prevention of tampering with the circuit.

The manner in which these hazards are removed, are, first, second, fourth and fifth by enclosing all live parts; third, interlocking access to the switch box when parts are alive; sixth, sealing of the enclosure or interlocking of the enclosure to prevent access in any manner with the parts alive or the bringing out of wires when the circuit is closed, except, of course, in a legitimate manner, and by persons who are duly authorized to do such work.

The above hazards exist always, but to a more or less variable degree depend on the capacity of the switch and the voltage of the circuit. The lower the voltage, the less the hazard from shock and burns becomes. However, except on very low voltages it would appear that full safety is worth while and not uneconomical, as the additional expense is slight.

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A. J. Wayman, The Wayman Electric & Manufacturing Company, East Palestine, Ohio: We are very glad, as manufacturers of safety switches, to have the opportunity of giving our opinion on what makes a safety switch safe.

First, the switch should be built to reduce the fire hazard; second, to protect the operator; third, to protect the maintenance man; and fourth, to protect the curiosity seeker or the person not familiar with electrical devices.

A switch to accomplish these purposes must be constructed along the following lines: An inclosed switch, externally operated. When the switch is closed the door or cover cannot be opened, and when the door is open, the switch cannot be closed. A spring attached to the switch so that it will make a positive quick make and break prevents the switch from making only a partial contact and also reduces the arc when opening the switch. The live parts should be protected so that when the switch is open a person cannot come in contact with same.

In case the quick make and break spring should become broken, it should not prevent the switch from being either opened or closed, or in other words put the switch out of commission.

To make a switch easy to install, the switch box should be in two parts, so that the sides and ends can easily be removed from the bottom of the box. This feature makes the enclosed switch as easy to connect up as an open knife switch, and it also protects the maintenance man when he inspects or repairs it since he can remove the part of the box that interferes with the accessibility to the working parts of the switch. It allows him to make quick adjustments, and without danger of becoming grounded on the sides of a deep box.

The interlocking feature should be of such a type that anyone in authority can close the switch when the door is open. Furthermore, the switch and parts should be ruggedly built and have as few working parts as possible. This will insure long life with a low upkeep.

Earl L. Thomas, Sales Manager, Aurora Steel Products Company, Aurora, Ill.: The following factors are considered necessary in safety switches:

1—Must be externally operated.
2—Provision must be made for locking switch open.
3—The box must be constructed in such a manner as to reduce danger from gas and fire if a short circuit occurs.
4—The switch proper must be constructed with proper spacing between the poles.
5—No springs or bars can be loosely attached inside the cabinet.
6—Cabinets should be constructed from steel which is sufficiently heavy to prevent flimsiness.
7—An arrangement should be made whereby the switch box cannot be opened when the switch is closed.
8—The switch box should be constructed in such a manner as to prevent closing the switch when the box is open.
9—Adequate wire spacing should be provided inside the cabinet.
10—The base of the switch itself should be made from a material that is substantial in every way.

Repairing and Rebuilding Electrical Equipment

(Continued from page 388)

and material sheets, Group *A*, Fig. 3, for that job. We can thus tell at any time just how much material has been used on a job.

The workmen make out a daily time ticket, Group *C*, Fig. 3, and a weekly time ticket, Group *C*, Fig. 4, showing the amount of time spent on each job. The use of a daily and a weekly time ticket gives us a double check on the time spent on jobs and thus prevents errors. The number of hours spent on a job is also entered by the cost department on the labor sheet, Group *A*, Fig. 3, for that job.

If, when a job is completed, the foreman finds that more material was drawn from the storeroom than was needed, he fills out a *Returned Material Credit Memo.*, Group *B*, Fig. 4, and sends this with the excess material to the storeroom. At the same time he notes in the lower portion of the proof sheet, Group *B*, Fig 5, the amount and kind of material returned. After checking over the returned materials, the storekeeper makes out a credit memo, Group *B*, Fig. 2 describing the amount and kind of material returned and sends it to the cost department where it is attached to the labor and material sheet, Group *A*, Fig. 3, for that particular job. Lastly, the foreman turns in his proof sheet, Group *B*, Fig. 5, to the cost department. The material requisitions and the credit memos are checked against the proof sheet to see that they agree, thus accounting for all material drawn from stock and insuring that neither more nor less than the proper amount of material is charged against the job.

Before a job leaves the department it is, of course, carefully checked by the foreman to see that the work has been properly done. In the case of rewound armatures about six times normal voltage is applied to detect grounds or shorts between coils and between coils and iron. Alternating current and a set of telephone receivers are used in testing for grounds and shorts between coils.

Before it is assembled, after all of the repair work is done, every piece of repaired equipment is refinished. For example, in the case of motors and generators a coat of Sherwin-Williams air-drying black lacquer is sprayed on the coils, the frame is given two coats of a good paint and all of the brass and copper work is polished.

Before motors or generators are shipped to a customer they are sent through the testing department where they are carefully tested and inspected to make sure that they are in perfect condition. In the case of a motor, readings are taken of the current and speed at no load and at full load, the kind and size of brushes used is noted, connections are checked up, and so on. All of this information is entered on the record card shown in Group *C*, Fig. 2. These cards, which measure 6 in. by 4 in. are filed in the testing department.

A complete description of the machine, with report of the examination, is also made in the form on the back of the yellow shipping ticket. This report form is shown in Group *A*, Fig. 8. This report is made in copying ink and an impression is made on the tissue sheet which is placed in the correspondence files.



How Do You Like My Stuff?

It's been some time since the editors have given me a place among the leading articles and I want to take this chance to ask you readers a very personal question —How you you like my stuff?

Be honest and refer to the first text page (in this issue it's 375), question and answer section, the jingle rhymes, such as the "Coil-Windin' Man," "He Cannot Read His Tombstone When He's Dead" and anything else.

If you want more of my stuff you will get it but if you want something instead, you will get that too—you're the doctor—what do you say?

Practical Pete

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Some Symptoms of

Transformer Troubles—

Their Diagnosis and Remedies

Compiled by H. E. STAFFORD,

Electrical Engineer,
Provincial Paper Mills,
Port Arthur, Ont.

(This table is continued on page 421)

SYMPTOM	TROUBLE	CAUSE	REMEDY
1 Temperature rises to danger point on oil-cooled transformer.	*A* Overload.	*A* Overload or low power factor.	*A* Reduce load or increase the power factor of the system. A 100-kw. transformer at 80 per cent power factor is fully loaded at 80 kw.
	B Not sufficient oil in tank.	*B* Due either to a leaky tank which will be readily noticed or not sufficient oil when transformer was installed.	*B* Add more oil and weld the defective part of tank. (Note: The core and coils should be fully immersed in oil.)
	C Oil jellied.	*C* Excessive heat. In a case of this kind the windings may be roasted and the insulation ruined.	If insulation is not damaged, flush the tank with new oil until all the old oil is removed and refill tank with fresh oil.
2 Temperature rises to danger point on air-cooled transformer.	*A* Overload.	*A* Same as cause in symptom 1.	*A* Same as symptom 1.
	B Not enough volume of air.	*B* Blower speed lowered or air ducts clogged.	*B* Speed up blower, clean out air ducts. (Note: In cleaning air ducts care must be exercised. If compressed air is used do not impress full voltage on windings immediately after, as there is always more or less moisture in compressed air. Half voltage should be impressed on low-tension windings and the high-tension windings short circuited. A transformer thus treated may be put back in service in about five hours.)
3 Temperature rises to danger point on water-cooled transformer.	*A* Overload.	*A* Same as symptom 1.	*A* Same as symptom 1.
	B Not enough water flowing through cooling coils.	*B* Pressure low or some obstruction in pipes.	*B* Increase rate of water flow.
	C Oil level below cooling coils.	*C* Oil leakage around water inlet.	*C* Stop leak and fill tank with fresh oil which should fully immerse cooling coils.
	D No water flowing through cooling coils	*D* Cooling coils plugged.	*D* Remove obstruction with water or air pressure up to 250 lb. per sq.in. but no more, as the coils are likely to be damaged. Where water contains lime or other impurities, the cooling coils should be cleaned at least every six months with a solution of equal parts of pure water and hydrochloric acid. This solution should be allowed to stand for not more than an hour and afterwards flushed with clean water.
	E Oil saponified on outside of cooling coils.	*E* Transformers operated at too low a temperature.	*E* If oil does not soften by over-heating, the cooling coils should be removed and scraped.
4 Explosions occur in transformer tank in addition to the above symptoms.	*A* Short circuit between adjacent layers of high-tension windings.	A^1 Moisture in oil (or air in case of air-cooled transformer.) Moisture in oil may be due to a leak in the cooling coil or to "breathing." Breathing or sweating is caused from operating the transformer in a damp location at too low a temperature. (Note: The temperature of a transformer should not fall below 10 degrees centigrade.)	A^1 Test for moisture in oil. This test may be made in two ways. The first is to measure the break-down voltage required to force a spark through a gap between two 1-in. disks immersed in the oil. Oil that is free from moisture should stand a break-down test of 25,000 volts when the disks are 0.1-in. apart. Where this apparatus is not available, the following test can be made. Heat a few crystals of copper sulphate (blue vitriol) on a hot plate, until the crystals turn white. Take a small bottle and fill with oil from the bottom of the transformer tank, as this is where the moisture will collect, and drop a few grains of the heated vitriol in the oil. Shake well, and if there is any moisture whatever in the oil, the solution will turn blue. If there is no moisture, the solution will remain a natural color. In getting a sample of oil, the best method is to use a long glass tube. Close the end held in the hand by placing the thumb over the opening. When the tube is fully immersed remove the thumb and allow the tube to fill. Again place the thumb over the top opening and withdraw, and the oil will stay in the tube. If moisture is present pass the oil through a filter press. After all the oil has been taken out the tank should be flushed with clean oil. The oil can be replaced as soon as filtered and the transformer immediately put back in service. (Note: Before testing the oil for moisture the transformer can be cut out of service and the service resumed on open delta if transformer bank is connected delta. If star connected all transformers in the bank become inoperative. When operating transformers on open delta, the load should be reduced to 58% of the load carried by the original bank.)
		A^2 Insulation broken down.	A^2 Replace sections of winding causing the trouble.
		A^3 Insulation punctured due to line surges.	A^3 Same as above.
		A^4 Shifting of coils due to switching on and off of heavy loads.	A^4 Same as above.
		A^5 Not enough insulation on the end turns. These should have from 2 to 5 times greater insulation than the inside turns.	A^5 Same as above and reinsulate end turns to proper thickness.
		A^6 Electromagnetic stresses too great, due to improper core construction.	A^6 Transformer will need to be sent to factory, to be redesigned. This trouble will be seldom met with.
		A^7 Transformer coils not properly baked before assembling.	A^7 Short circuit primary or high-voltage windings and impress about half voltage on low-tension windings.
		A^8 Lightning discharge without protection.	A^8 Repair damaged coils or replace with new coils. (Note: All transformers should be protected by having choke coils or reactors in series with them.)
		A^9 Oscillating currents caused by conductors swinging together due to wind storms.	A^9 Same as A^2.
		A^{10} Unstable voltage, generator voltage not steady.	A^{10} Same as A^2.

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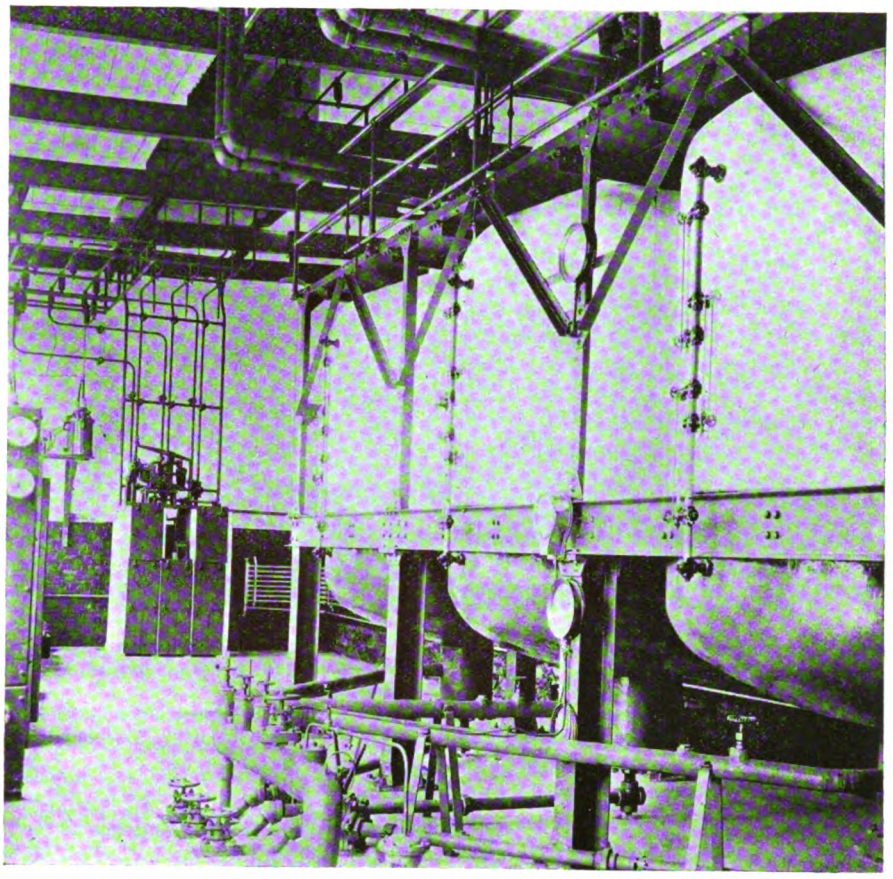
ONE MAN PER SHIFT does all the work in connection with two 2,500-boiler-hp. electric boilers for the Laurentide Company, Grand Mere, Quebec. Formerly thirty-seven men were required to get the same amount of steam (75 tons per hour) from fourteen coal-fired boilers. In addition the handling of 50,000 tons of coal per year is eliminated.

New Uses of Electric Steam Boilers

And the Results Secured in Several Mill Installations

By P. H. FALTER

Vice-President, The Electric Furnace Construction Co., Philadelphia, Pa.



One man handles these three 1800-boiler-hp. electric boilers which operate on 22,000 volts. These boilers take three-phase, sixty-cycle energy and evaporate fifty-five tons of water per hour at 125 lb. pressure for the Brown Company, Berlin, N. H. This is the highest voltage at which any steam generators operate. Each set of three units is rated at 18,000 kw.

UNDER CERTAIN conditions the electric steam boiler is an economical means of making steam. The main condition for successful operation is that cheap electrical energy be available during at least part of the time.

This energy may be surplus power purchased under a block rate but not used. With such conditions the money saved on coal may often pay for the electric boiler in a short time. A boiler of this type requires no heavy foundation or a large building. It has no smokestack and no fuel storage, handling or stoking. The operation is simple and requires few men. There is no smoke, dust or ashes. The boiler has a thermal efficiency in the neighborhood of 97 per cent and it will generate steam at any pressure. The repair charges and stand-by charges are quite low. Refractories and other parts subject to high temperatures are eliminated since the highest temperature is that of the steam.

The accompanying table shows the range of voltages, capacities, sizes, and so on. Alternating current at 220 volts up to 22,000 volts has been used on single-phase, two-phase and three-phase systems. Steam pressures varying from 4 lb. to 220 lb. are secured and the boilers supply as high as 100,000 lb. of steam per hour at 125 lb. gage. Water heaters give up to 3,000 gal. per minute raising the temperature 15 deg. F.

The electric boiler generates steam by passing current directly through the water. In its simplest form the water-resistance boiler is nothing but a water rheostat. Such a heater is very nearly perfect in efficiency. All the energy put into the boiler or heater passes into the water. The only losses which are possible are a loss due to radiation, which can be kept at a low value by proper heat insulation and a small loss from bleeding or blowing down to get rid of the impurities left behind when the water is evaporated. The opportunity for inefficiency as a result of carelessness on the part of the attendant or total lack of attendance is very small. A single attendant per shift can easily look after two or three units, since his principal duty is to keep the water at the proper level.

The first boilers of this kind were designed by F. T. Kaelin, chief engineer of the Shawinigan Water & Power Company, together with the writer. On these boilers iron plates bent to the arc of a circle were employed as electrodes. These were suspended from conducting rods within the boilers so as to hang concentric and thus parallel with the neutral shell which formed a protective lining for the boiler shell proper. This construction, while fairly satisfactory does not lend itself to adjustments which are sometimes necessary. Round electrodes were tried, using two or three in a tank, but these are not as satisfactory as the concentric electrodes from the viewpoint of making definite calculations of current distribution. Both of these methods are limited to use in smaller boilers, up to 7,500 kw., and for voltages up to 2,300.

For higher ratings, and particularly for higher voltages, the multiple-tank design is generally employed. This design is equally satisfactory for small boilers, but it is somewhat higher in first cost than the one-tank design. For three-phase power three tanks are used and two tanks are used for two-phase supply. Each tank is a separate single-phase boiler, having one cylindrical electrode suspended from its center by

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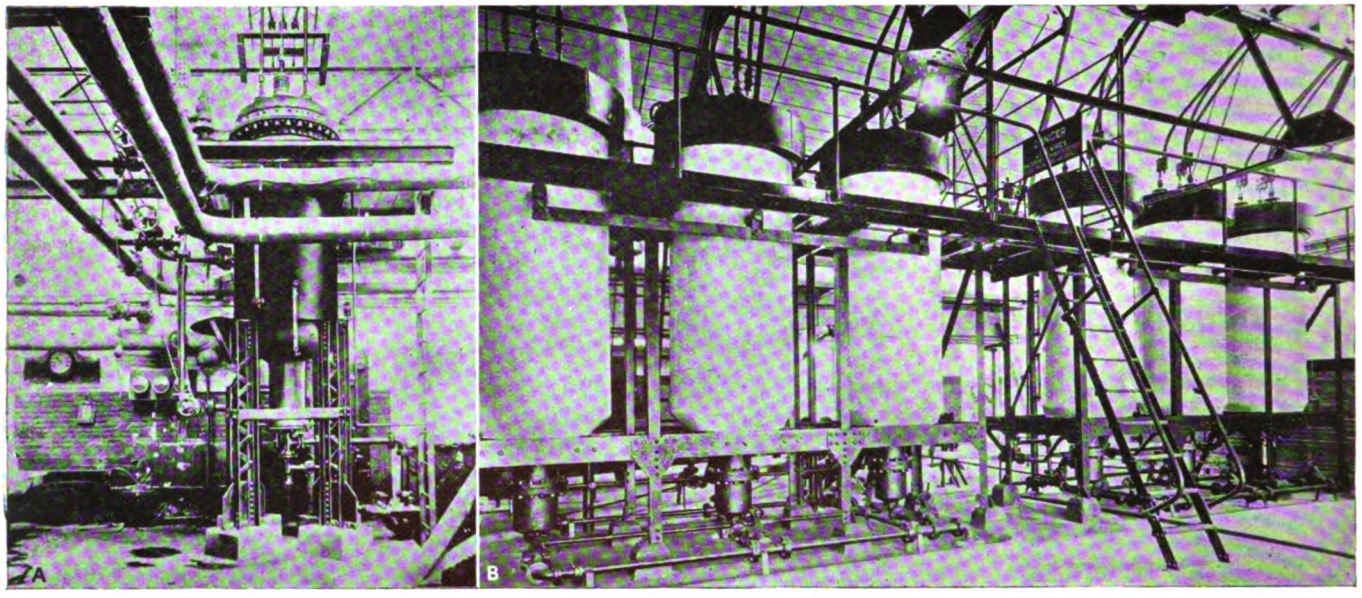


Fig. 1—Two electric boiler installations which produce steam very cheaply.

At *A* is a 5,000-kw. (500-boiler-hp.) unit installed at the Wayagawamack Pulp and Paper Company, Three Rivers, Quebec. The two 25,000-kw. sets at *B* are the largest electric boilers in operation. They operate on 6,600 volts, three-phase, sixty-cycles and each delivers 77,500 lb. of steam per hour at 135 lb. pressure. They are in the plant of the Laurentide Company, Grand Mere, Quebec.

one or more supporting rods or cables which serve to bring in the current. The water supply and bleed for each tank are manipulated independently so as to keep the same amount of power flowing through each tank, and thus balance the phases on a polyphase system. The steam is piped into a common header.

In designing an electric boiler or water heater all boiler code rules and special State regulations must be complied with. The only conditions which limit the design are atmospheric pressure, water-service pressures, and low, standard and high steam pressures. The selection of the correct operating voltage may have an important bearing on the efficiency of the boiler. Also the question of current densities must be properly investigated. A boiler that will meet one condition of water may not be suitable for another. Even the frequency employed influences the design.

Boiler-feed waters vary greatly in electrical conductivity and this must be carefully taken into consideration when selecting the boiler. No chemicals should be added to the feed water for electrical boilers.

The fact that the height of the water in the tank controls the power input and thus the amount of steam generated, renders an electric boiler nearly automatic. For this reason additional automatic control equipment was found merely to complicate the operation without giving any corresponding advantages. Many of the so-called automatic devices have the habit of failing at a critical time and such accessories often require more attention than the main apparatus. On the large electric boilers a man is always in attendance and it is a simple matter for him to keep watch on the water levels.

There is little that can go wrong in a properly designed electric boiler. On high voltages insulators give some trouble and electrode wear must be allowed for. However, voltages as high as 22,000 volts are used with practically no trouble. The wear on the electrodes is usually not over a few inches per year and consequently they do not have to be renewed oftener than about once a year. Of course safety valves are installed on these boilers, but there is also another guard against excessive pressure. Automatic circuit breakers (or fuses for small boilers) are connected in the supply wires and these cut off the current if the pressure goes too high. Abnormally low water which is so much feared in coal-fired boilers means only a lower steam production in the electric boiler and in case the water falls below the ends of the electrodes the current flow in the boiler is simply shut off.

These boilers have been particularly applicable to pulp and paper mills for generating process steam. In general, however, any plant which uses steam and hydro-electric energy might find that an electric boiler is economical for either intermittent or continuous use. Among the industries to which this applies are the pulp and paper, lumber, chemical, laundry, textile, dye, food, cement, fertilizer and others.

Cheap electrical energy is present in different ways in different plants. For instance one plant purchases energy at a block rate paying for a certain amount of power whether it is used or not. During part of the day and on week ends some of this power is not used. Consequently an electric boiler was installed. The present cost of making steam is considerably lower than the cost of making it with coal. In fact the boiler paid for itself in a few months.

As an example of the possible saving suppose a company buying such power has a surplus as follows which is paid for but not used:

100 kw. available 11 hr. each week day; 200 kw. available 12 hr. each week day at night; 300 kw. available 16 hr. each Sunday:

This amounts to:

100x11=1,100 kw.-hr. each week day
200x12=2,400 kw.-hr. each week day at night
3,500 kw.-hr. each week day.
3,500x 6=21,000 kw.-hr. available during six week days
300x16= 4,800 kw.-hr. available on Sunday
25,800 kw.-hr. available per week

If 25,800 kw.-hr. is divided by 7, the quotient, 3,700 kw.-hr., is the average electric energy that is available each day.

Now 1 kw.-hr. will evaporate 3 lb. of water, hence 3,700 kw.-hr. will make 3,700 x 3 =11,100 lb. of steam per 24 hr. In other words, this is the amount of steam that can be gen-

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Ratings and Sizes of Electric Steam Boilers

This List Shows the Range in Voltage, Capacity, Size, and So Forth of Some of the Standard Electric Boilers That Have Been Made

Volts	Kw. Normal Rating	B. H. P.	Lbs. Steam Per Hr. At 125 Lb. Pressure	Overall Dimensions		
				Length	Width	Height
550	350	35	1,000	5′ 0″	4′ 6″	9′ 3″
550	600	60	1,750	5′ 0″	4′ 6″	9′ 3″
1,100	800	80	2,300	5′ 0″	4′ 6″	9′ 3″
1,100	2,000	200	5,800	6′ 0″	5′ 0″	11′ 3″
2,200	1,300	130	3,800	5′ 0″	4′ 6″	9′ 3″
2,200	3,200	320	9,300	6′ 0″	5′ 0″	11′ 3″
2,200	5,000	500	15,500	7′ 0″	6′ 0″	13′ 6″
4,400	1,800	180	5,300	6′ 0″	5′ 0″	11′ 3″
4,400	6,000	600	18,000	12′ 0″	6′ 0″	13′ 6″
6,600	8,000	800	24,500	12′ 0″	6′ 0″	13′ 6″
6,600	20,000	2,000	60,000	20′ 6″	11′ 0″	13′ 6″
12,000	24,000	2,400	73,000	25′ 0″	13′ 0″	15′ 0″
22,000	18,000	1,800	53,000	.....	.....	.....

erated in an electric boiler by consuming electric energy that has already been paid for and that would otherwise be wasted.

Assuming that 1 lb. of coal makes 6 lb. of steam this would require 1,850 lb. of coal. At $8 per ton this equal $7.40 for coal per day. Therefore with the electric boiler the saving would be $2,700 per year of 365 days. The cost, f. o. b. Philadelphia, of a 350-kw. electric boiler is $2,500. The installation cost would be $500, making a total of $3,000. The saving on coal would therefore pay for the electric boiler in less than a year and a half.

The electric boiler has made possible the development of certain pulp- and paper-mill projects in Canada and elsewhere, which would have proved uneconomical if coal had been necessary. As an example, which is typical of that practice, we may assume a paper mill requiring 1,800,000 lb. of steam in 24 hours. This will require a boiler of about 23,800 kw. capacity. If this steam were generated by coal giving an evaporation of 9 lb. of water per pound of coal, then 89 long tons of coal would be required daily. At a price of $8 per ton under the boilers this would amount to $712 per day, or $213,600 for a year of 300 days. These figures are entirely reasonable, and in fact are in favor of the coal-burning boiler. If the power for this boiler is available without additional expense the boiler will pay for itself within a few months. It is possible, furthermore, to build a generating plant or enlarge a present one in some cases provided the water power is available. This can be done at a saving over the operation of coal-fired boilers. Let us take for instance the case just mentioned. If we capitalize the annual coal bill as 10 per cent for interest and depreciation it will give us a total capital allowing an expenditure of $90 per kw. installed for the hydro-electric plant to operate the electric boilers. This cost would have to include the transmission line, but neither step-up nor step-down transformers would be required if the generators were chosen of a voltage to suit the boilers. If the transmission line were very short probably much less than $90 per kw. would be sufficient. For instance, at $75 per kw. the electric boiler would compete with coal at $6.67 under the boiler. At $60 per kw. for the electric plant the cost for steam would be the same as for coal delivered under the boilers at $5.33 per ton.

In New England there are many plants which have small streams dammed to develop a small amount of power. Much of this water is allowed to (*Continued on page 422*)

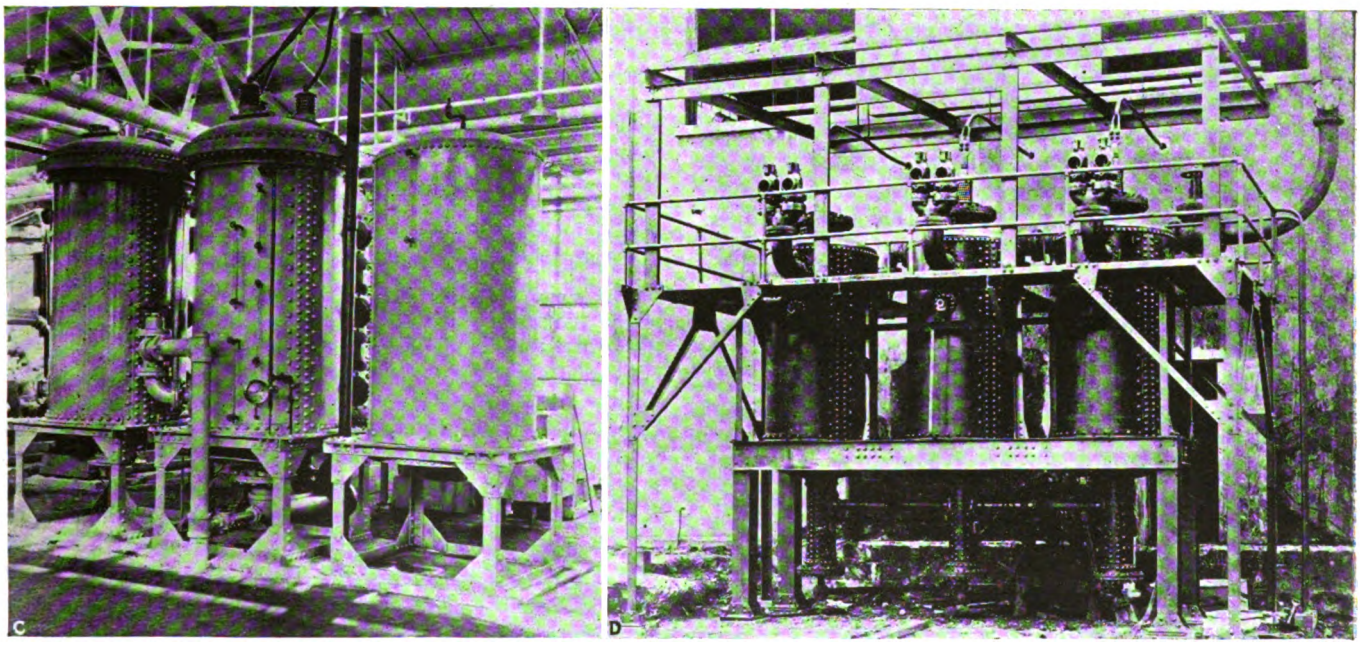


Fig. 2.—A large boiler and a water heater which use electrical energy as the source of heat.

The 1,800-boiler-hp. steam generator at *D* occupies, with its fittings and platform, a space of only 21 ft. by 10 ft. 3 in. by 22 ft. The boiler is rated at 18,000 kw., 12,000 volts, three-phase, 25 cycles and evaporates 54,000 lb. of water per hour at 125 lb. pressure. The boiler is owned by the Niagara Falls Power Company, although it is installed in the plant of the Cliff Paper Company, Niagara Falls, N. Y. At *C* there are shown two water heaters in the plant of the Ford Motor Company, Green Island, N. Y. The heaters are rated at 3,000 kw., 4,600 volts, three-phase, sixty cycles.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, August, 1923

Have the Courage of Your Convictions!

INDUSTRIAL MEN, particularly those who have dug their practical experience out by hard work and hard thinking, frequently voice their difficulty in putting across their ideas in contrast to others who are better talkers. Sometimes they feel that those in authority try to talk them down and merely offer objections just to be contrary. Such, however, is seldom the case. What are often considered as objections, even though so worded, are usually a sincere desire to find out all about the proposed idea before going to the expense of a trial.

One general manager of a very large enterprise is considered by his associates as a particularly hard man to convince on the practicability of new ideas. One of his younger associates who has been particularly successful in "selling" ideas to his superior, attributes this success to the ability to anticipate any objections, operating conditions or possibilities which might arise in practice and by being able to show how his suggestion would meet it. Thinking ahead will eliminate many false ideas and it is cheaper, and easier, to think than to try costly experiments. Also clear thinking forms the basis of clear argument.

How another practical man who had the courage of his convictions finally won out by persistence is shown by the following letter which was received from a reader with a contribution for the "Service Around the Works" department of INDUSTRIAL ENGINEER:

> I am sending for your approval, a description of the job of which I am the most proud. I don't suppose you can realize the difficulties under which I labored to get permission to make this test. It was turned down by our head engineers, by their consulting engineers and by the engineers who built the equipment. They proved (on paper at least) that the loss in heat in the rheostat would more than balance the saving in power, also that the motor speed would not be stable.
>
> However, I had done this before on a small scale and having the courage of my convictions I kept on and eventually won over our superintendent who agreed to take a chance (on the quiet). Not much was said at the actual test run, but somehow, on pay day, I was not much surprised to find an increase amounting to about 10 per cent of what I was saving for the company. I was recognized at last as "a practical man."

Perhaps other readers have installations of which they, too, are proud and on which they have won out through persistence and clear argument and have received the recognition and reward for it. If so we would like to publish the details.

Progress Follows the Question Mark

THE FIRST automobiles were provided with whip sockets. Finally someone asked *why* and there was no reason except that buggies (the earliest automobiles were adapted buggies) always had been built that way. Almost every farming community tells a true story of a neighbor who is "kidded" about carrying a binder whip after he had hitched his reaper up to a gasoline tractor. He, too, was following habit or years of precedent without asking why.

Recently the Chicago Tribune stated that their business manager asked "Why provide sash locks on windows of a skyscraper?" and thereby saved $1,000 in a hardware bill. Probably he saved an equal amount by eliminating their installation expense on a new building which the Tribune has under construction. After all it is not very likely that anyone will crawl into the windows on the tenth or twentieth floor of a skyscraper.

How many other things are being done every day that are unnecessary? Simply because someone did them that way once is no reason for a habit so firmly fixed that everyone thinks that it is indispensable and must be continued forever.

Men in industrial plants have big opportunities for asking "why" in the work they do. Why is this made in two parts? Why are two bolts or screws required instead of one? Why is the work done this way? Why is it put together as it is? These and many other questions if answered will bring out economies which are essential to keep down the cost of production. Progress results from initiative and a determined effort to answer the question "Why?"

Are You Getting Ready for the Big Job?

"SOME DAY the Big Job will come along and I'll have the answer to it while you fellows are running around and trying to find out where to start." This was the reply of a young repairman to some of his fellow workers who were making sarcastic remarks about the time he "wastes" in filing wiring diagrams and other useful information in a large scrap book, of which he is very proud.

Time spent in collecting and filing information that one may find useful in his work is never a waste of time. Rather, it is a form of preparedness that is probably too seldom practiced, although it is something that no one who is interested in his job and in his future can afford to overlook. Most of us have more than once been suddenly confronted with a knotty problem, and could remember that we had seen the answer to it, somewhere, sometime, but when we needed it we could not find it. Merely to know that there is an answer somewhere does not help much in an emergency. The fellow who wins recognition is the one who knows exactly where the answer is and can produce it whenever necessary.

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Technical magazines publish a very large amount of extremely useful information, much of which is the result of years of experience. But, unless the various issues of the magazine are kept for reference, or the tables, diagrams and other usable data clipped and filed, finding them two or three years later—when the Big Job comes along—may be very difficult or impossible.

Strain at a Gnat and Swallow a Camel

EVERY successful business man takes pride in the belief that he gets very nearly 108 cents value, and perhaps more, for every dollar he spends. That is one of the reasons why he is successful. Often, however, he overlooks the fact that the effort he makes to get "his money's worth" when a motor or other piece of equipment is purchased is effective only insofar as the purchase price and the quality of the equipment are concerned. The manufacturer charges a price which is in keeping with the quality and true worth of the equipment and sees that it is in proper working order when it leaves his factory. Whether the purchaser will realize the full value of his investment depends on how the equipment is cared for after it is placed in service.

Practically every item of equipment used in industrial work needs some maintenance attention. Bearings wear down in time, contacts become burned, insulation slowly deteriorates and in a multitude of ways service exacts its toll. Unless this toll is paid in the shape of proper attention and care the purchaser of the equipment cannot hope to secure from it the full service which it is capable of giving, when operated under the proper conditions. He will not get back the 100 cents expended and the 8 cents as a net production profit.

It is highly illogical for the management of an industrial works to make too much ceremony over securing and comparing bids when buying equipment in order to make the best bargain possible, and then, after the equipment is installed, practically forget all about it. In the one case a comparatively few dollars may be at stake; in the other, hundreds or thousands of dollars may be involved.

Straining at a gnat and swallowing a camel evidently is not confined to biblical times.

Things the Eyes Do Not See

OBSERVATION is a great asset that is usually keenest after years of experience and the accumulation of information that automatically causes the eye to make more or less subconscious comparisons. The physician who is a successful diagnostician after years of practice is respected and perhaps trusted more than the younger physician, not so much on account of the difference in scientific training, but because of the larger and broader experience that years of practice have provided.

A fuller knowledge of science has, however, furnished instruments and devices that compete with experience when placed in the hands of an analytical observer. In industrial work the portable graphic recording meter is such an instrument. And its indications are so sensitive and so accurate that things which get past the experienced eye are plainly brought to the attention of one less trained and at a time when this knowledge will make it possible to remedy the trouble thus located, with the least trouble and expense. The use of the graphic meter referred to by Mr. Funderburg on page 375 of this issue in the testing of a geared drive brings out this particular point.

In most plants we have a tendency to be too satisfied with conditions as they are and looking for trouble is sometimes an unpopular job. But after all $200 to $400 worth of testing instruments and a man who knows how to use them at a salary of say $3,600 per year, is an insurance protection against lost time in production, damages to machines, and spoilage wastes, of about 40 per cent when these troubles amount to $10,000 per year and 4 per cent when they amount to $100,000 per year. Even in the first case the prevention of a break in a lineshaft, the burn-out of a 500-hp. motor, or the stopping of rolls in a steel mill, will make the expenditure of $4,000 a year a profitable investment, when compared with the probable loss that might result when operating conditions of machines and circuits are judged solely by inspection with the eye.

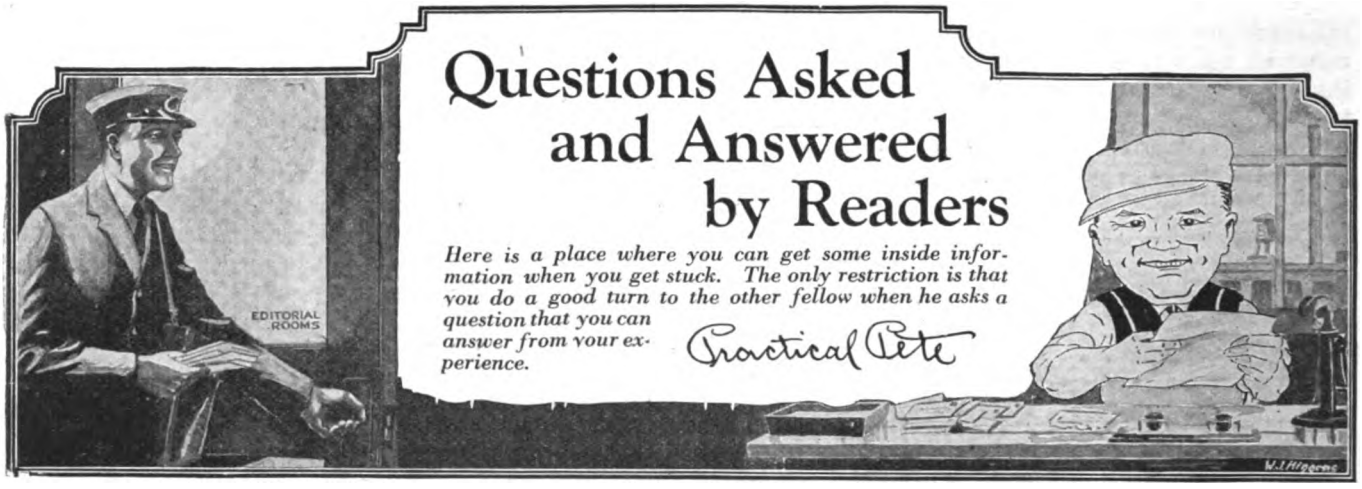
Accident Prevention Is Cheap Production Insurance

IN A RECENT bulletin issued by the United States Steel Corporation these significant facts are presented on accident prevention: Since 1906 when intensive safety work was begun, serious and fatal accidents in its plants have been reduced 56.13 per cent and 35,313 men have been saved from serious or fatal injury. Since 1912 disabling accidents have been reduced 71.41 per cent which means that 193,232 men have been saved from injury. During 1922 in 136 plants and mines employing an average of 55,639 men, some operations were carried on from two to six months without a single disabling accident.

In making such records possible something like $12,000,000 have been expended in improving physical conditions of plants and in education of workmen to maintain their interest and co-operation in safety work. At present there are employed 125 safety engineers and supervisors who devote their entire time to accident prevention and the improvement of working conditions. More than 55,209 employees have served on safety committees since 1908 and at present 8,912 employees are serving on such committees. These plant safety committees are made up of operating officials, foremen, master mechanics, skilled workmen and men from the rank and file of the plants who make inspections, investigate accidents, recommend means for preventing similar accident and conduct special investigations of particular problems.

Employees in large plants such as are operated by the Steel Corporation have a right to expect safe working conditions, but they have an individual responsibility as well in maintaining safety standards and in observing safety regulations that have been adopted for their protection. The steel company, like many other large organizations, is making the marked headway outlined through a combination of engineering revision in plant operations and education which shows results in reduced disablement, less time lost and increased production—results which indicate that accident prevention, largely viewed as a necessary humanitarian activity, has also a practical and economic aspect.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Design of a Growler for Testing Armatures—I wish some of the readers of INDUSTRIAL ENGINEER would tell me how many turns and what size wire to put on a laminated core in order to make a growler for testing armatures up to 50 hp. in size. This core is 8½ in. x 4 in. x 4 in., and has a 1¼-in. slot cut into it. If necessary I could make the core longer. Alternating current of 110 or 220 volts is available for operating the growler.
Canton, Ohio. R. M.

* * * *

Removing Insulation from Enameled Wire—I should like to know if any of your readers know of a quick method of removing enamel from magnet wire, other than scraping with a knife. I find it takes a great deal of time for this operation in winding a motor and I would be very grateful if someone can tell me of an easier method.
Avenel, N. J. J. U.

* * * *

Voltage from Transformers Connected in Different Ways—I should like to get an expression from readers of INDUSTRIAL ENGINEER as to their experience in connecting transformers open delta, closed delta and star. Please show, if possible, a sketch covering each of these connections and the voltages at 2,300, 1,100 and 440 volts. Perhaps someone can tell me where I can purchase a book which covers such subjects.
St. Louis, Mo. F. W. Mc.

* * * *

Changing Two-Phase Motors to Three-Phase—In our plant we have sixteen motors ranging from 3 hp. to 50 hp., making a total of 210 hp. These motors are wound with four to eight poles. We are considering putting in additional equipment and I shall appreciate it if some reader will answer these questions: (1) Would it pay to change over to a 3-phase system? (2) What saving would there be, if any, in power consumption? (3) Would it be necessary to rewind these motors to change them from 2-phase to 3-phase? (4) Would such a change increase the efficiency of the motors?
Jeannette, Pa. A. W. G.

Testing Series Field Coils for Short Circuits—I wish some of our readers would tell me the best way to test series field coils for internal short circuits. We use 600 volts direct current for power purposes and have no instruments on hand except a 600-volt voltmeter. Whatever outfit or equipment is recommended, will you please state where it can be purchased and what the complete outfit will consist of? I should also like to know if the outfit will prove satisfactory in the case of dead shorts as well as high-resistance shorts.
Albert, W. Va. F. H.

* * * *

Changing Single-Phase Motor to Three Phase—I have a single-phase, 12-pole, 48-slot, 600 r.p.m. exhaust-fan motor in which the running winding consists of 54 turns of No. 17 wire per pole in two slots. This winding is connected in parallel. I shall appreciate it if some reader can tell me if it is possible to rewind this motor for 220 volts, three phase. If so, how many turns per coil should there be? What should the pitch be? Please show a diagram of the connections.
Shreveport, La. G. R. L.

* * * *

Operating Two Direct-Current Generators in Parallel—We have in our plant two 300-kw. d. c. generators. These machines are wound series compound, are equipped with equalizers and are connected in parallel. They are in continuous operation, except that once in 24 hours they are shut down for about 10 minutes for cleaning. We leave the resistance on the shunt field in the same position as when running, as there is no load on the machine. We trip the breakers and pull the equalizing switches out. I should like to know, however, if the machine is likely to be damaged in starting up again in case the engineer should shut down with the resistance fully cut in on the shunt field and both breakers tripped, but with the equalizing switches in. The running voltage of this machine is 250 volts. When starting up with the resistance cut in the machine does not build up the voltage. I should like to know what voltage the incoming machine would build up with the shunt resistance cut fully and receiving its only excitation from the other machine through the equalizer.
St. Louis, Mo. F. G.

Ammeters Connected for Three-Phase, Three-wire Circuits—I wish some reader of INDUSTRIAL ENGINEER would give me a wiring diagram of three ammeters used on a three-phase, three-wire circuit, using only two current transformers, and explain how the current passes through each meter.
Haledon, N. J. G. Z.

* * * *

Method of Determining Resistance—Will some of the readers of INDUSTRIAL ENGINEER please tell me what method they have found best to determine the resistance in the following cases: (1) When a faint noise is heard when testing for a ground or a short-circuit with a 2200-ohm telephone receiver and 6-volt dry cell what is the resistance? (2) When testing with a 2200-ohm receiver and a 2-volt dry cell? (3) When testing with a 75-ohm receiver and 6-volt dry cell? (4) When testing with a 75-ohm receiver and a 2-volt dry cell? (5) What takes place in a 112-volt Mazda B lamp installed on a 110-volt circuit, when the inside of the glass gets black? I believe a lower voltage was the cause of these lamps getting black but I cannot understand just what chemical action has taken place to cause it.
Philadelphia, Pa. A. C. D.

Answers Received To Questions Asked

Armature Insulation—What is considered the best types of slot insulation that varies from 5 to 10 mils in thickness, considering pliability, mechanical and electrical insulation and deterioration in stock?
Albert, W. Va. F. H.

In answer to the request of F. H. in the May issue for the best type of armature slot insulation, I want to express my opinion. I surely hope that if F. H. is really looking for good material he will heed my suggestion, which is the result of eight years of armature winding experience, during which time I was, and am yet, very much interested in the kind of insulation used.

To my mind, the best all-around

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slot insulation I ever used is what is called in the trade Armco paper, made and sold by the Allied Rubber & Mica Company, Cleveland, Ohio. This is without doubt the very best I have used, and I use it now in every possible instance. The next best is what is known as Red Rope paper. These two papers are tough, pliable, hard to tear, good dielectrics, and will stand a lot of hard usage and mechanical stress. The Armco paper is especially useful when winding soft coil armatures, where the coils have a tendency to bulge as they come out the sides of the core, this being where the greatest mechanical strain is and where many kinds of paper will crack.

The Red Rope paper is also an excellent paper, not quite as tough as Armco, but it has the very good property of being easily shaped when used for insulating the core ends, the back of commutators and in the neck of the armature. This paper should be thoroughly wetted and allowed to stand for a few minutes after it is cut to shape. This wetting makes it soft and pliable and it can easily be formed and rolled into shape with a warm rolling iron or piece of steel. As an armature slot insulation I like it next best to Armco, but it has a very fibrous texture that makes a rough-looking job when the papers are cut off at the top of the slot, unless the knife used is very sharp.

I hope F. H. will try these papers and I am sure he will be satisfied. The Red Rope paper comes in rolls and the Armco in 30-in. x 40-in. sheets. GEORGE WM. HANLON.

Darby, Pa.

* * * *

Voltage between Transformer Neutral and Ground—I am looking for information which I am sure some of our readers can furnish. In a primary star connection with the neutral grounded, machine rating 4,000 volts, three-phase between phases, what voltage, if any, would there be to ground when three single-phase transformers of 2300-volt rating are star-connected to the primary side and the secondary side connected 440 volts delta? Also, what would it be if the secondaries were connected 440 volts star on the secondary side?

Elkhart, Ind. R. A. D.

In the June issue of INDUSTRIAL ENGINEER R. A. D. asks what will be the voltage to ground on a 4,000-volt, three-phase, grounded neutral system using 2,300-volt transformers with the primaries connected star and the secondaries connected star or delta.

As R. A. D. has not mentioned any grounding of the transformer, the only grounding being on the supply system, there will be no voltage to ground on the secondaries, but there will be a voltage of 4,000 divided by 1.73=2,310 volts from the primary supply lines to the ground.

So long as the insulation between the windings in the transformers remains intact there will be no voltage from the secondaries to ground.

Boston, Mass. EDWARD A. GIBBS

* * * *

Reversal of Rotation of Watt-hour Meter—There are two questions I should like to ask the readers of INDUSTRIAL ENGINEER.

(1) We have an Ingersoll-Rand compressor, driven by a Westinghouse synchronous motor. When this motor is started by an auto-starter the watt-hour meter will run in a forward direction, but as soon as the switch is thrown into the running position, the meter reverses its direction of rotation. By adjusting the field excitation up to 20 amp. the meter will run forward or in the proper direction, but as we have to run this motor with a field excitation of 35 amp. the meter will again reverse and run backward as soon as this current value is reached. This is a polyphase, watt-hour meter and the power factor never goes below 70 per cent. What causes this reversal?

(2) We are about to install four 300-hp., 2,200-volt, 3-phase, 60-cycle motors rated at 69 amp. per motor, or a total of 276 amp. What size polyphase watt-hour meter should be purchased in order to take care of the four motors?

Iron River, Mich. A. J. E.

In reply to A. J. E.'s question, I believe you will find that your watt-hour meter is improperly connected up, assuming that you have a 3-phase watt-hour meter and not two single-phase meters. At a power factor of 70 per cent lagging it is possible to connect up a 3-phase watt-hour meter so that it will correctly indicate the kw. input, but give an incorrect reading at any other power factor. If you had two single-phase power factor meters connected to this circuit, you would find that one meter will reverse under certain conditions but a polyphase watt-hour meter should run in a positive direction regardless of the power factor.

With reference to the size of watt-hour meters which should be used with the four new motors, it is customary to install a watt-hour meter of rating 50 per cent in excess of the maximum rating of the circuit it is to be used on. This is to take care of heavy starting current and overloads. If the four motors you mention are to be run together, I would recommend a 2,000-kw. watt-hour meter using 500-5 current transformers, but if you want light load accuracy, and the four 300-hp. motors are not going to be started together, I believe you would secure better results by putting in a 1500-kw. meter.

If after checking the connections, both internal and external to your watt-hour meter, you still find that the meter rotates in both directions, I shall be very pleased to give you any further information that you need if you will let me know and if possible show in a sketch the connections as you now have them.

Detroit, Mich. A. C. ROE.

* * * *

Starting Trouble When Rheostat Was Changed—I have a 2-hp., 230-volt motor connected to a drill press. The rheostat burned out recently and I made use of a 5-hp., 115-volt rheostat which was all we had. When starting the motor with this rheostat it ran in the wrong direction. We tried to reverse the direction by changing the armature leads and changing the field leads. This did not change the direction of rotation. The motor is a two-pole type shunt wound. Please advise why the direction of rotation was not changed when changing the connections and also how the direction of rotation can be changed.

Indianapolis, Ind. H. T. F.

With reference to the question by H. T. F. in the April issue regarding the cause of reversal of a 2-hp., 230-volt motor when the rheostat was changed, I think that he must have, in some way, changed the field connection running to the no-voltage release coil on the rheostat. Probably he substituted a rheostat of a different type. Then in changing connections he states that he changed both the field and armature connections. Changing either one would reverse the motor, but it would not be reversed by changing both field and armature leads. A 5-hp., 115-volt starter would give a 2-hp., 230-volt motor very little starting protection.

C. M. FLUKE.
Manager,
Raystown Water Power Co.,
Roaring Springs, Pa.

* * * *

In the April issue of INDUSTRIAL ENGINEER, H. T. F. asks why the shunt-wound motor reversed when a new rheostat was installed and why the direction of rotation was not again changed when he changed the position of the armature and field leads.

The cause of the change in the direction of the rotation of the motor was probably due to his getting the leads connected to the rheostat crossed, thus connecting the positive lead to the negative side of the circuit and *vice versa*.

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Then when he tried to reverse the direction of rotation he reversed both the field and armature leads, so that the relation between them was unchanged. If he had altered only one set, either field or armature, he would have found that the motor reversed, but it will not do so when both are transferred to the other side of the circuit. G. H. McKELWAY.
Westfield, N. J.

* * * *

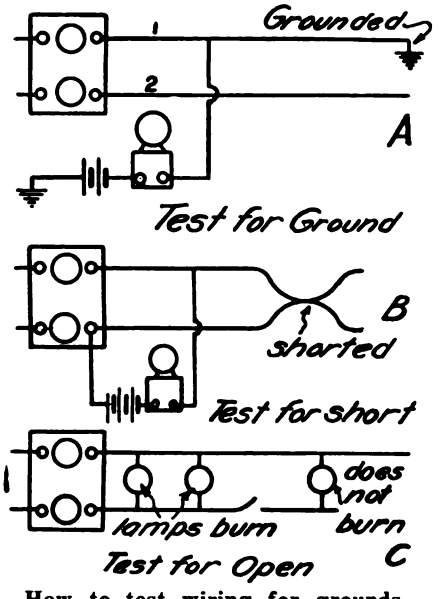
In the April issue, H. T. F. describes a starting trouble which developed when a rheostat was changed. It is really guesswork to try to determine without more details just why the direction of rotation of the 2-hp. motor was reversed, but the following explanation is very probable. I assume that the new starting box was connected properly, the connections checked and that the motor was compound wound.

Suppose that the series and shunt fields had been bucking each other right along, but that the load had never been so heavy that this was discovered. When the 5-hp., 110-volt starting box, which has five times the current-carrying capacity of the 2-hp. starting box, was installed, the armature and series-field circuits were made to take much more starting current than previously and the series field therefore overpowered the shunt field, causing the motor to run in the opposite direction while starting. The motor was probably stopped at once and the whole series field and armature circuit reversed outside the motor in an effort to reverse the armature circuit. This reversal would naturally not change the direction of the rotation as the series field still established field flux in the same relation to the armature flux as before. Then the shunt field was reversed with no better results. The shunt field was weak, compared to the series field, and the last change merely brought it in the same direction as the series field. I would suggest that the connections to the starting box be carefully checked and the motor tested for grounds and other defects; next that the shunt and series fields be connected so as not to oppose each other.

Then if the motor still runs in the wrong direction, it should be reversed by reversing the leads at the brushes. W. E. PAULSEN.
Des Moines, Iowa.

Locating Trouble in Wiring Circuit—I would appreciate suggestions from readers on the best scheme for testing B X wiring circuits for troubles such as short circuits and grounds, which does not require taking out switches and receptacles or dropping of canopies of lighting fixtures.
Brooklyn, N. Y. H. F.

Concerning the query by H. F. in the April issue of INDUSTRIAL ENGINEER, regarding the testing of wiring circuits to locate trouble, I believe that the accompanying diagram will show clearly a good method of procedure. With the lamps taken out and the fuses removed from the cutout a ring obtained when either cutout terminal is touched with one lead of the test set, while the other lead is grounded, indicates that there is a ground on that side of the circuit.



How to test wiring for grounds, shorts and open circuits.

This condition is shown in *A*. With the fuses and lamps removed, a ring obtained with the test set across the cut out terminals, as in *B*, indicates that there is a short circuit between the circuit wires. In case of an open circuit somewhere in the system, with the service connected and fuses and lamps in place the lamps on the supply side of the open circuit will be lighted. To test for an open circuit when the power supply is not connected, connect the test set across the cutout terminals, after the fuses and lamps have been removed. Beginning with the outlet closest to the cutout, short each one at the socket with a screw driver. Ringing of the test set will indicate continuity of circuit up to the outlet which is being shorted. Failure to obtain a ring, when an outlet is shorted, indicates an open circuit between this outlet and the last one from which a ring was obtained. JOHN B. RAKOSKE.
Detroit, Mich.

* * * *

In answer to H. F.'s question in the April issue of INDUSTRIAL ENGINEER, on locating trouble in wiring circuits, I suggest the following procedure: Set in the off position all switches and sockets on the circuit in which there is trouble, with the exception of the circuit switch in the distribution cabinet, (if there is one). This switch must be closed. If one plug fuse is blown, replace it with a 25- or 40-watt lamp. If the lamp lights up and you are sure that all outlets on the circuit are turned off, you either have a short or a ground. If removing the plug fuse from the circuit puts the test lamp out, you have a short circuit; if the lamp remains burning you have a ground. To locate a ground, find the center of the circuit by counting the outlets. Then open the center outlet in the circuit and examine the splices for a bare spot. If there is none, test for the live side to ground and open the live wire. If the test lamp goes out the ground is back of the open circuit; if the lamp remains lighted, the ground is ahead of the open circuit. This method of testing should be followed out until the ground is located.

To find a short circuit, the procedure described above should be followed with the exception that both the lamp and the fuse plug must be in the circuit. On a trouble job, where the lines are dead, a magneto or a bell and dry cells can be used. JOSEPH B. HUMPLEY.
Blatz Brewing Company,
Milwaukee, Wis.

* * * *

Crane Collector Wires—On a five-ton alternating-current crane, having a bridge or cross travel of about 50 feet, we have experienced considerable trouble with the collector wires sparking at the contacts. Both types of collectors have been tried out; namely, shoes and wheels, and we have been forced to use flexible cables to do away with standard collecting devices.

Can readers tell us what the trouble is and how they overcome such difficulties in practice, for we do not feel it should be necessary to resort to the method we have adopted?
New York, N. Y. M. K.

I noticed in the July issue of INDUSTRIAL ENGINEER an answer to a question asked by M. K., in the February issue. For M. K.'s benefit I may say that I have had quite a lot of experience with various makes of

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cranes, ranging from 5- to 150-tons capacity, and am glad to give him the benefit of this experience. On one occasion I had trouble similar to that described by M. K. with a 15-ton a. c. crane. Sparking was caused by the wires being drawn too tight, which is not necessary on small-tonnage cranes using small gage wire if sufficient space is available. However, we did not have much space between the shoes; so we rigged up another trolley arm on the outside of the bridge, large enough to take all wires with lots of room between. I am of the opinion that bored shoes such as are supplied by the Niles Co. for trolley service are the most efficient, but for main collectors I prefer wheels, small in diameter but with a wide groove. If the crane is located in a foundry or other dusty place it should be blown off weekly, if possible, and a very small amount of vaseline or good quality grease applied to the collecting devices.

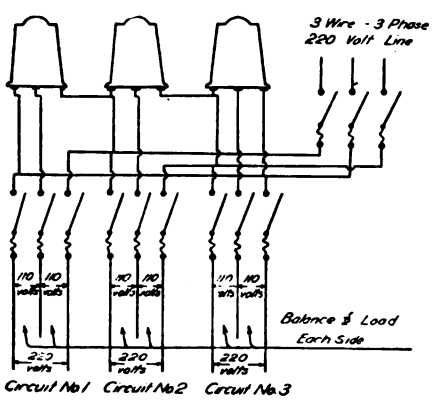
LACHLAN A. MCEWAN.
Montreal, Canada.

* * * *

How to Secure 110- and 220- Volt Service from 220-Volt Generator—We have a 7.5 kva., 3-phase, 220-volt, 60-cycle self-excited a. c. generator that we desire to use at night for lighting the boiler and turbine room and some residences across the street. I would like to have some reader tell me what transformer connections I can use to obtain 110 or 220 volts on the secondary side, so as to balance the load on all three phases. Would it be possible to use a balance coil with a three-wire secondary? If so, I would like to see a diagram of connections that will be most satisfactory.
Henderson, Ky. J. M.

For the information of J. M., who asked in the April issue how to connect balance coils to reduce from 220 to 110 volts, the accompanying sketch shows a method I have found very efficient and which I sincerely hope will help J. M. with his little problem. The coils shown in the sketch are manufactured by the American Transformer Company, of Newark, New Jersey, but I am sure that J. M. can purchase, from any manufacturer of his preference, coils to meet his requirements. With all praise for INDUSTRIAL ENGINEER, best regards to Practical Pete, and more power to him in his good work.

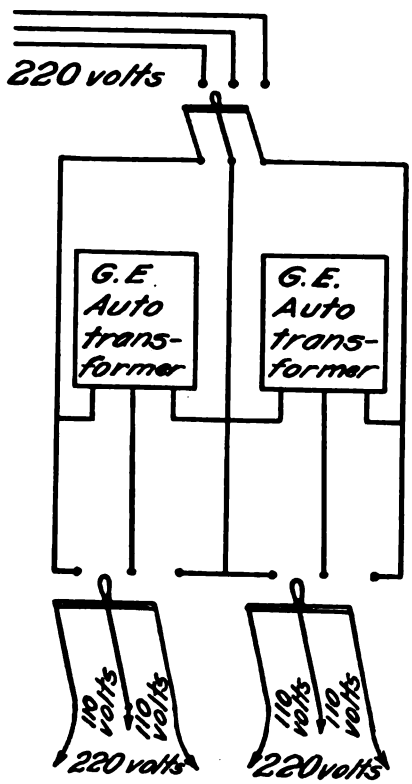
E. H. SCHRIVER.
Assistant Chief Electrician,
Irvington Smelting & Refining Works,
Irvington, N. J.



Connection of balance coils for 110 and 220 volts.

* * * *

J. M. asks, in the April issue of INDUSTRIAL ENGINEER, how he can secure 110- and 220-volt service from a 220-volt, 3-phase generator. The accompanying diagram shows how two General Electric auto-transformers can be connected so as to give him the service he desires.



Two G. E. auto-transformers connected to give 110 or 220 volts from 220-volt service.

Paterson, N. J. K. MANTEI.

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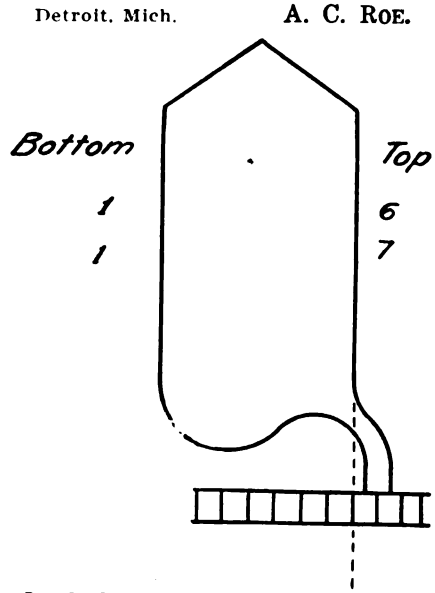
Rewinding Desk Fans—We have to rewind 16-in. desk fans of Westinghouse and Colonial make, and I would appreciate it if some of the readers will answer the following questions: How many turns and what size wire should I use for the armature coils? What is the coil pitch? There are twelve slots and twelve bars in the Westinghouse fans and fourteen in the Colonial. When the armature is mounted in the winding machine should the upper end be turned toward the operator or away from him when winding? Should the leads be brought out on the side nearest to the operator, or on the opposite side? What is the pitch of the commutator leads and does it make any difference whether I swing them to the right or to the left? This is a lap winding, and there is more wire in the last coil than in the first coil, assuming the same number of turns on all coils. Will this cause sparking at the brushes?
St. Louis, Mo. W. G. W.

In reply to the question by W. G. W. on rewinding fan motor armatures in the May issue of INDUSTRIAL ENGINEER:

(1) I do not have any winding data on these as we have found that it is cheaper to carry a stock of new armatures rather than to rewind those which are burned out. (2) The coil pitch for the 12-slot loop winding is 1 and 6, and for the 14-slot loop winding it is 1 and 7. (3) It is immaterial which way the coils are started, or in which direction the coils are wound so long as they are all wound alike. (4) It makes no difference on which side the leads are brought out, providing they are all brought out alike and on the commutator end of the armature. (5) These armatures are generally connected straight out as shown in the diagram. The leads are thrown one bar away from the line out from the top slot, the throw being away from the center of the coil. (6) With small, hand-wound armatures, loop windings, each coil has a different resistance due to each succeeding coil being larger. This has no effect on the electrical operation, but causes a mechanical unbalance.

All of the above points are mentioned in the two articles "Winding Small Armatures" that appear in the January and February, 1922, issues of INDUSTRIAL ENGINEER.

Detroit, Mich. A. C. ROE.

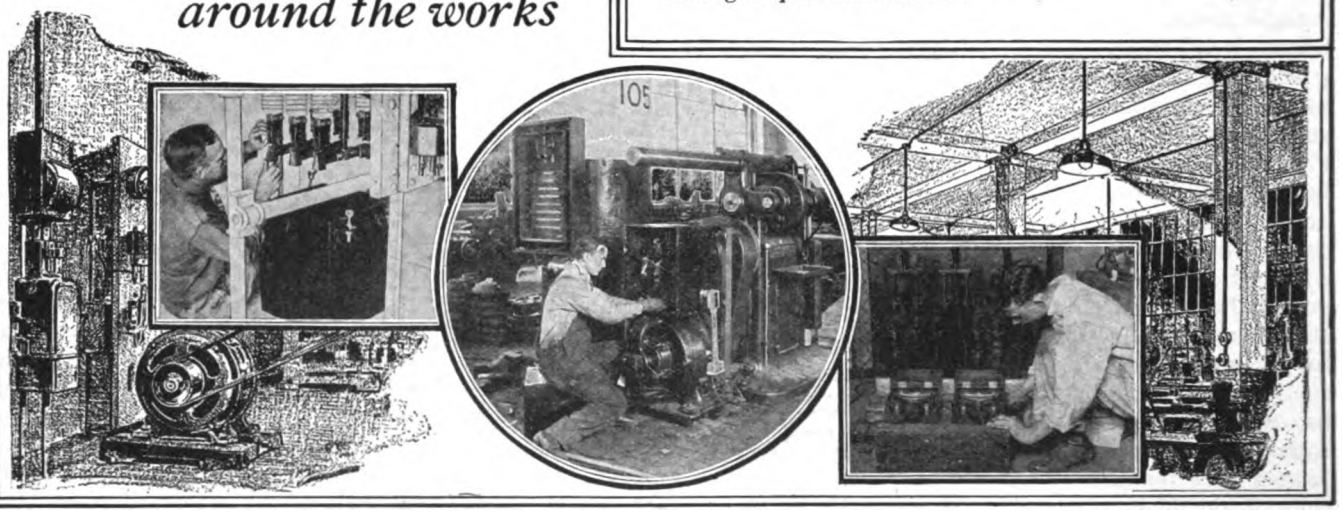


Lead throw for fan motor armatures.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

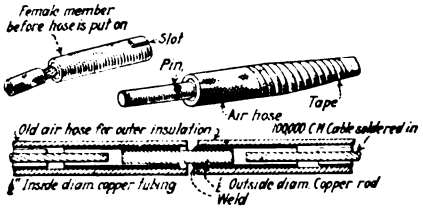


Convenient and Simple Bayonet-Type Connector for Welding Leads

A SIMPLE, quick-action connector for arc-welding leads which has been giving satisfaction for about two years in a large shipyard is shown in the accompanying drawing. It is easily handled, carries the current without overheating and will stand a large amount of abuse.

The connector is essentially a simple bayonet-type joint made from ½-in. inside diameter copper tubing into which a piece of ½-in. *outside* diameter copper rod (or tubing) is thrust and locked by a one-eighth turn. The contact area is about 2 in. long. Short pieces of copper tubing and old ⅝-in. air hose sufficient to make several dozen connectors were fished out of various scrap piles and made up at odd times.

It is the custom for each welder to have a short length, about 6 ft., of extra-flexible small cable. One end of this short cable is equipped with the male half of a bayonet connector to plug into the end of the regular 100,000 circ. mil. cable, while the other end is arranged to carry the electrode holder.



This single-conductor connector for welding leads is rugged and quickly detachable.

In the yard where these connectors are used it is not uncommon to see as much as 700 ft. of cable between the motor-generator set and the arc. The connectors have paid for themselves many times over through time saved in moving, clearing up tangles, extending leads, and cutting out damaged sections.

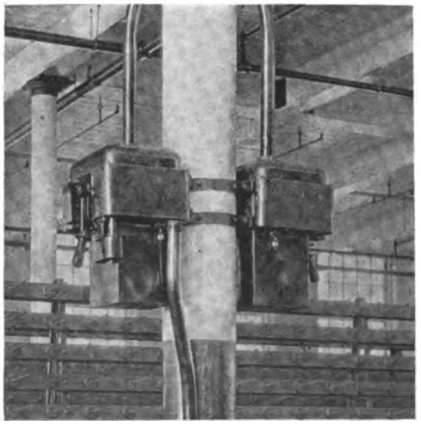
Bremerton, Wash. R. H. DAVIS.

Neat Method of Mounting Two Control Switches on One Column

WHERE two pieces of control equipment are to be mounted on one column, it will be difficult to find a better appearing mounting than that shown in the accompanying illustration. This shows two oil switches used for the control of motors in a southern textile mill. Four iron straps are employed to hold the switches. Each of these straps is bent to conform to the shape of the column, and makes about one-sixth of a turn around the column. The straps are made secure on the column by means of lag bolts and the switches are bolted on to the straps with their backs to the column as shown.

The conduits running upward from the switches to the motors pass through holes in the covers. These covers may be slipped upward on the conduits if it is necessary to have access to the inside of the switch in order to inspect it or change connections.

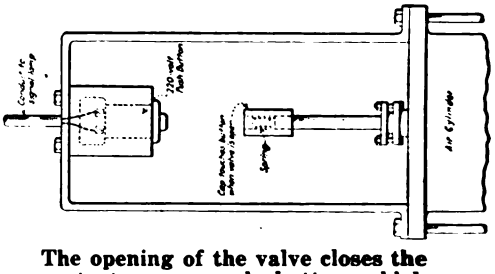
R. S. HUNTINGTON.
Greenville, S. C.



The two oil switches are bolted to iron straps which are fastened to the column.

Lamp Indicator Shows Which Air-Operated Valve on Tank Has Opened

THE WRITER has worked out a scheme to show at a distance when air-operated valves, which are used on the measuring tanks in the American Beet Sugar Company's plant at Oxnard, Calif., are opened. We have mounted 220-volt push buttons on light iron frames, as shown in the accompanying sketch, so that



The opening of the valve closes the contact on a push button which causes a signal lamp to light.

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they will be operated when the pistons of the valves are in the open position. On the end of each piston is placed a small iron cap with a spring inside so that the pressure on the push button will not be too great.

The circuit from each button goes to a corresponding lamp, behind a glass panel, which is numbered according to the number of the tank and so identifies the valve which has opened.

W. W. PEASGOOD.

Chief Electrician,
American Beet Sugar Co.,
Oxnard, Calif.

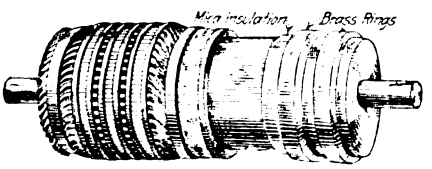
Easy Method of Obtaining Alternating Current from D. C. Machine

IT OFTEN happens that alternating current is required for some experimental work or testing when only direct current is available and the cost of a small alternating-current generator to be driven from a direct-current motor would be too high to warrant its use. Such a problem can quite often be solved at little expense by simply fixing collecting rings on the commutator of some direct-current motor or generator that is available, as indicated in the accompanying drawing.

If the machine to be used is to run as a motor, the commutator should be long enough to allow room for some of the regular brushes to remain on it to drive the machine as a motor, in addition to the room required for the collector rings. The machine must have a range of speed to cover the frequency desired. This can easily be figured, as the r.p.m. equals (60 times the frequency desired) divided by (half the number of poles in the machine). This means that a two-pole machine running at 3,600 r.p.m. will give 60 cycles, as: $(60\times60)\div(2\div2)=3{,}600$. A four-pole machine must run at 1,800 r.p.m. to give 60 cycles, because: $(60\times60)\div(4\div2)=1{,}800$. Lower frequencies require proportionately less speed.

Insulate with mica or other good insulating material a portion of the commutator wide enough for the rings to be mounted on. Force on the rings, shrinking them on if possible, after which they should be turned smooth and round. Each ring is then connected to one commutator bar on a two-pole machine, two commutator bars directly opposite each other for a four-pole machine, and so on, or 360 electrical deg. apart. For single phase, which requires two rings, the second ring is connected to commutator bars 180 electrical deg. from those of the first ring. For three phases the connections of each ring are 120 electrical deg. apart.

The rings are best made of brass and the connections to the commutator bars can be made with small set screws that are set down into the rings and pierce through the insulation onto the different commutator bars. The effective alternating voltage obtained is 0.707 times the direct-current voltage.



Alternating current may be obtained from collector rings mounted on, but insulated from, the commutator and connected to the proper bars, as explained in the text.

PHILIP G. BERNHOLZ.

East Orange, N. J.

Additional Steps in Making Endless Leather Belts for Transmission Purposes

IN THE June issue of INDUSTRIAL ENGINEER, on page 309, appeared some information on "Making a Belt Scraper," one of the most useful tools for a belt man. Also in the July issue, on page 365 appeared an item on "Making Laps for Cemented Endless Leather Belts for Industrial Purposes." In both instances the information was based on the experience of The Leather Belting Exchange, an association of leather belt manufacturers. The present item is based on a third contribution containing additional suggestions on the preparation of the belt and its lap for cementing.

Belts which are to be made endless may be divided into three classes:

(1) Those which have been endless, and which it is desired to shorten. (2) Those which have been running with a laced or metal fastened joint. (3) New belts which have not yet been placed upon the pulleys.

When deciding how the work is to be done these again divide themselves into two classes: (a) Those which are small enough to be thrown off the pulley and taken to a nearby bench and, (b), those which, because of their size, must be worked upon on the pulleys.

After a belt has been running endless, but has stretched a little, so that the tension is reduced, it becomes desirable to shorten it. If it is a narrow belt, which may easily be thrown on the pulley after splicing, it is first necessary to determine how much shorter the belt must be. When this is decided, find the joint which was made when the belt was last put on, or a joint which is opening, and, with the point of the screwdriver, carefully open it, by running the screw-driver under the point of the lap and working it towards the heel, as shown at *A* in the accompanying illustration, at the same time taking care not to tear the leather.

If it is a double belt each ply of leather may have its own lap, or if it is a narrow belt it may have such a lap as is used on a single belt. Remove the narrow belt to the bench; inspect carefully to see from which end it is most desirable to cut, in its relation to any other joints in the belt, and then bring the end on which it is decided to work nearly to the end of the bench; clamp the belt to the bench with bench clamps, as shown at *B*, and proceed to cut back the laps the desired distance.

When it is desired to substitute an endless joint for a laced or hooked joint the procedure is a little different. If the belt is loose enough on the pulleys so that it can be shortened the length required to make the endless joint, the process consists in removing the belt to the bench as before, and making the necessary lap. If it is a single leather belt, or if it is a narrow double, say under 6 in., an ordinary single lap may be used, as illustrated. This lap should be from 4 in. to 6 in. long, according to the width. The process then may be completed as described. If the belt is an old one, and the surface of the lap when made appears to be greasy, it should be cleaned with gasoline before attempting to cement it.

Where the belt is not long enough to provide from its stretch sufficient material for the lap, it becomes necessary to prepare a piece to set into the belt. If it is a single belt, this may be a very short piece with a lap on each end, as illustrated at *C*; then laps must be cut upon the old belt to fit this piece and the cementing process applied as described. Where it is a narrow double belt, the

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piece inserted may be made in exactly the same way. For a wider double belt the piece should be arranged so that it provides a separate joint for each of the two plies of the double belt, with these two joints "broken" so that they do not come together. This type of joint is illustrated at *D*. The ends of the belt then may be fitted to this insert.

With wider belts or those which cannot be carried conveniently to the belt bench it is necessary to work with belt clamps. If an old belt is to be shortened, first find the point on the belt at which the joint has been made, and bring the belt around to a place between the two pulleys where it may be most convenient to work. Then put on the clamps, with jaws conveniently spaced on each side of the joint.

In putting on belts with clamps the first requisite is to see that the middle line of the width of the belt corresponds exactly with the middle line of the distance between the centers of the rods of the clamps.

The next point, a most imperative one, is that each pair of jaws of the clamps shall be exactly square with the edges of the belt. A little care here in drawing up evenly on the two rods will bring the two ends of the belt square and true, and will save effort and a crooked belt.

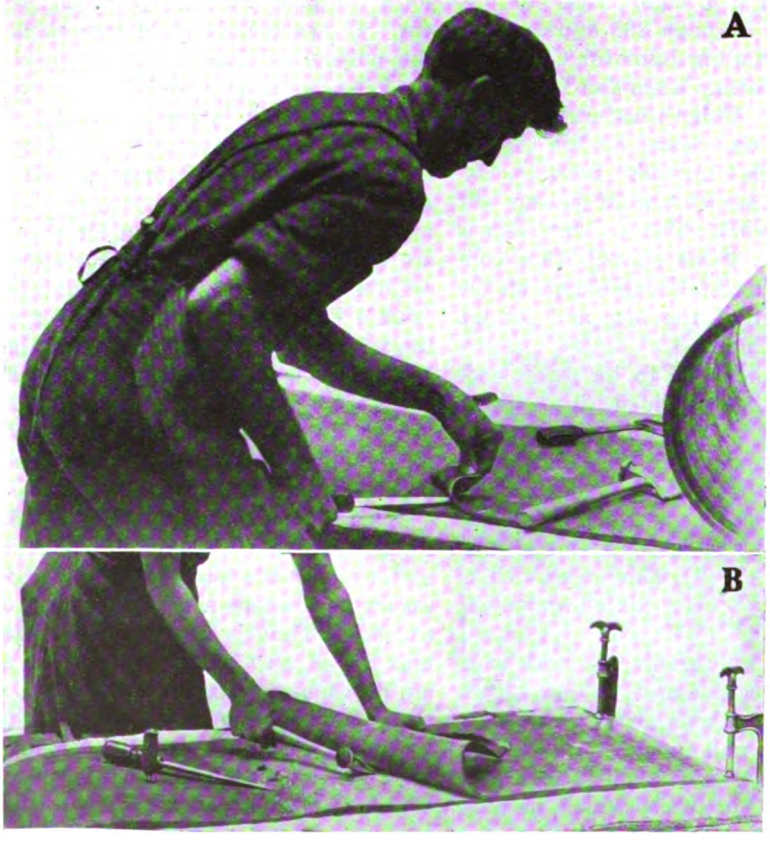
Apply enough pressure to the clamps to take the tension of the belt off the joint, and then open the joint with the screw-driver, as before, cut down the new lap on one end with the spokeshave and the scraper, scrape off all the old glue from the lap on the other end, as described on page 365 of the July issue, and proceed as before. This work can be best done on a clamp board, which fits between the side rods of the clamp and is attached to them.

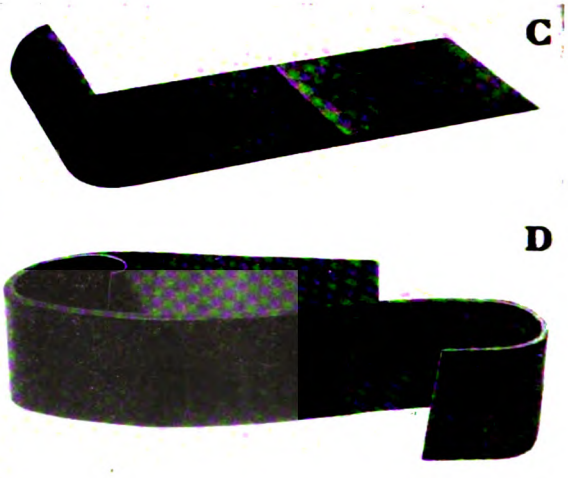
In putting on new belts the laps should be made at the bench, the belt drawn over the pulleys and then the clamps adjusted as above described. If a belt is to be purchased for that installation, give the belt maker the exact length around the pulleys, stating whether it has been measured with a steel tape, a cotton tape, a wire, or a string, and let him make the allowances, and tell him to make it "endless-open laps." Measurements made with other than steel tape are not reliable. It then will come to hand ready to be placed around the pulleys and cemented.

In the case of new belts which it is desired to place on the pulleys endless, the first thing is to get the proper length of the belt. It is usual to estimate that the belt should be one-eighth of an inch to the foot, or 1 per cent less than the actual steel tape measure around the pulleys, and for small belts, which are to be thrown on the pulleys, without the use of clamps, this will be found to be sufficiently accurate. For those belts which are to be put on with clamps, or where it is necessary that the belt shall be tight to produce tension, this allowance may be increased slightly, but not much. For single belts, to this length must be added the length of one lap. The belt may be cut to this total length, and the laps prepared and cemented as described in the previous item.

For double belts, the plies should be opened for a little distance from the ends of the belts. This distance must vary with the width of the belt, and consequently the length of the lap desired, as well as with any other joints which may be near the ends. It may be desirable to make it long enough on one side of the belt or the other to include an existing lap, so that two of them shall not come close together on the same side of the belt. This distance must be long enough so that each lap will have a piece of whole leather on the opposite side. When this distance is determined one side of one end and the opposite side of the other end must be cut back the proper distance, as shown at *D*. Then the laps may be made on both of the two sides, on both of the two ends, as described.

Usually new belts can be prepared best at the bench. If it is a belt of





Steps in the opening up of joints and cementing in sections when making leather belts endless.

A. If a leather belt is already endless, or if it is desired to remove a section of the leather, it is best, whenever possible, to take it apart at a joint. For this a blunt edged tool, such as a screw driver, is used, as shown, to pry the edges apart. **B.** Double leather belts are opened up in the same way, although after the edge is started it is often possible to use a blunt-edged hatchet to speed up the forcing apart of the joint. **C.** When it is desired to splice a belt which has used lacing or metallic fasteners, the belt is usually too short to supply material for a lap-joint and a section (**C** shows insert for a single belt) must be cemented in. **D.** This section is to be cemented into a double leather belt.

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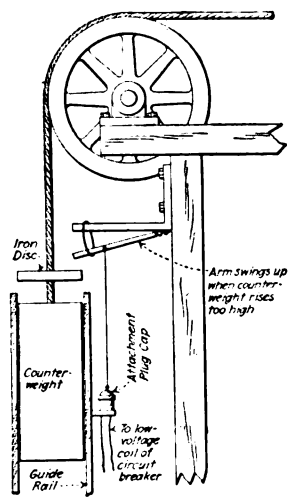
any size it may take some effort to bring the two ends close enough to slip the clamp rods into place. Clamps for very wide belts usually are made with a heavy screw-eye bolt in one of each pair of blocks, so that a chain hoist, or a block and tackle may be used to bring the ends of the belt together. With a new belt it is necessary to pull it up to a point where the laps fit perfectly. If proper allowances have not been made and the belt is too long the lap must be scraped back to shorten it, unless a big error has been made.

It is generally agreed among belting men that single belts should be put on so that they have an initial tension, before starting, of 72 lb. per in. of width, and double belts in proportion. Ordinarily, there is at hand no method of measuring this tension, and it becomes a question of judgment of the operator which he can get by watching the performance of his belts after they have been running.

LOUIS W. ARNY.
Secretary,
The Leather Belting Exchange,
Philadelphia, Pa.

Safeguard to Keep a Hoist from Overrunning by Stopping Motor

BECAUSE the limit switch from the lime-kiln hoist in our plant has failed to operate several times an additional safeguard has been installed. This consists of an attachment plug having a cap whose terminals are short circuited. The circuit from the low-voltage-release coil of the hoist circuit breaker is run through this attachment plug and the short-circuited cap. As shown in the accompanying drawing the cap is so arranged that if the counter-weight should travel too high in its path it will strike an arm which is attached by a string to this cap. This will throw the cap out of the plug and thus open the circuit to the low-voltage-release coil, which will stop the hoist motor.

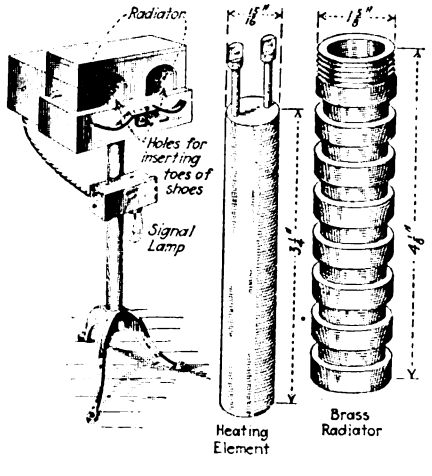


When the counterweight travels too high the cap of the plug is pulled out. This opens the circuit to the low-voltage-release coil.

W. W. PEASGOOD.
Chief Electrician,
American Beet Sugar Co.,
Oxnard, Calif.

How to Make an Electrically-Heated Tank for Vaporizing Water

WATER can be vaporized for humidifying or manufacturing purposes in easily made devices similar in general design to the one which is described in this article and used for steaming the box toes of shoes. For this service a tank of 2 qt. capacity requires 750 watts and when so equipped the hourly evaporation will be 1 qt. of water when its initial temperature is 60 deg. F.



Details of an electric vaporizer which is used for steaming shoes.

The box toe of a shoe is placed in each of the semi-circular openings. Radiators containing heating elements may be seen through the openings. A separate detail of the radiators and 150-watt heating element is also shown. The rectangular cover for catching the steam is made of sheet copper. The lamp shows whether or not the current is on.

The water container consists of an open-top, cast-iron box 4½ in. wide and 3½ in. deep and as long as required. Screwed into one side of this box and projecting into it are special cast-brass radiators, as shown in the illustration. These are spaced 1⅛ in. apart. A 150-watt heating element 15/16 in. in diameter by 3¼ in. long is then placed in a 1-in. hole drilled into one end of each radiator.

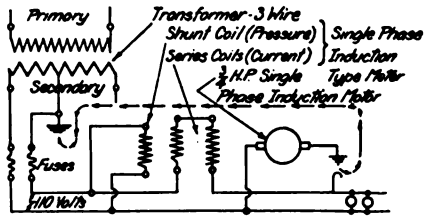
The radiators are automatically kept submerged by means of a float and needle-point valve in a water reservoir which is capable of supplying the water to a number of vaporizers. The water container is insulated with a covering of asbestos over the bottom, sides and ends. The container is then placed in a larger sheet metal box and mounted on a pedestal of suitable height. The outer box is large enough to protect the connections at the back of the heating elements. Two copper busbars mounted on porcelain insulators are run the entire length of the water box and the leads from each heating element are connected to the buses.

ALBERT KOCHS.
Chief Engineer,
Hamilton Brown Shoe Co.,
St. Louis, Mo.

Motor Lead Grounded to Conduit Shunts Out a Meter

USUALLY an accident to the wiring or equipment means a loss to the owner but a peculiar condition which was not detected for some time actually saved us money, although it was at the expense of the power company. As will be seen from the accompanying illustration, we have a ¾-hp. single-phase induction motor and a lighting circuit which are connected through the same meter. One of the leads to the motor had broken off at a kink inside the conduit. One end of this lead had, through constant vibration, come in contact with the grounded conduit and the consequent arcing had practically welded the wire and conduit together. It will be seen that when the switch was closed the motor operated but the meter did not register as one side of the circuit was made between the motor and the transformer through the ground, thus causing an unintentional theft of power.

Leads *A* and *C* should be connected to *D*, and *B* should be connected to *E* in order to prevent loss of energy through a ground return and still maintain the proper direction of rotation of the meter disc.

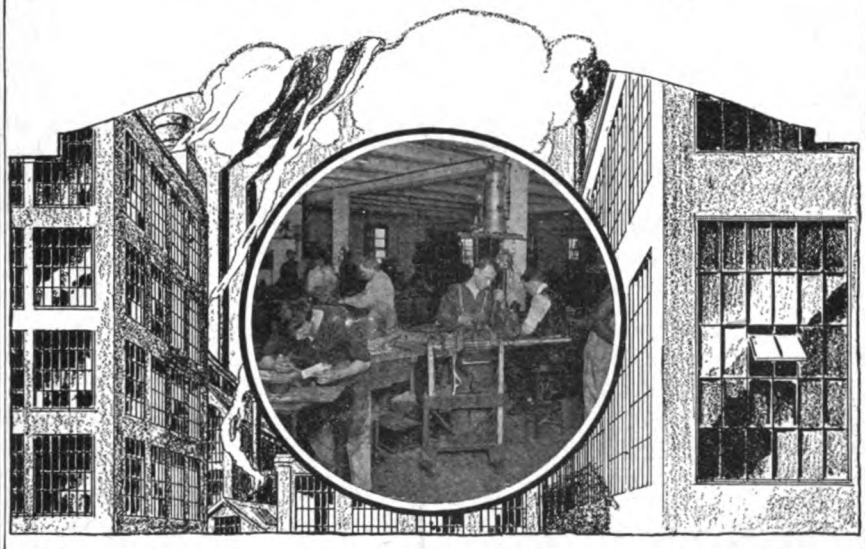


When a motor lead became grounded to the conduit current flowed from the conduit to the grounded transformer, preventing the meter from registering.

HONOLULU, HAWAII. ALLAN H. CUNHA.

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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

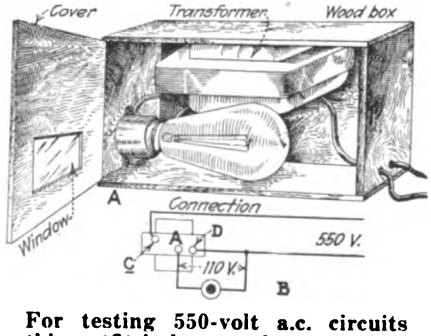
Easily Made and Compact Testing Lamp for Use on 550-Volt A. C. Circuits

WHEN making tests on 550-volt alternating current circuits, instead of using the customary five lamps mounted in series on a board we use a small transformer and one lamp, as shown in the accompanying illustration. The advantage is that only one lamp is needed, which means that only one-fifth as many lamps need be replaced on account of breakage. This outfit is smaller and easier to carry than the five lamps in a bank, as ordinarily used.

This little testing device consists of a wooden box containing one of the small transformers used in connection with the no-voltage release on K-20 Canadian General Electric oil circuit breakers. As desired, box can be arranged, as shown, with the lamp inside and a window in one side of the box, or the lamp can be placed in a sign receptacle screwed on the outside, in which case a smaller box may be used.

J. H. SAUVE.

Reardon Pulp and Paper Company, Timiskaning, Quebec, Canada.



For testing 550-volt a.c. circuits this outfit is less cumbersome than five lamps in series.

A Complete Winding Data Card For A. C. and D. C. Machines

RECENTLY I have had occasion to collect winding data for a large number of motors of different makes and the accompanying illustration shows a motor and generator data card which I am using. It has been found very convenient for this purpose. As will be seen, this card, which measures 6 in. by 4 in., can be used for compiling winding data for either a. c. or d. c. machines, and when properly filled out gives about all the data that would be required.

I am interested in cards and card systems for the collection of information of this nature and I am showing this card not because I think it is the best that could be worked out, but have made this contribution in the hope that other workers in this line will show what they have found best suited to their needs. In this way, we can all profit by the experience of the other fellow and a better data card will be the result. Accurate and complete winding data is such an important part of the motor repairman's equipment that I feel that the problem of keeping the data in such form that it can easily be found when wanted is worth a good deal of attention.

V. G. WEBER.

Portland, Ore.

What form of card have you devised for collecting winding data for motors of various makes and types?

OREGON INSTITUTE OF TECHNOLOGY — WINDING DATA CARD NO. ____

MACHINE — MAKE Westinghouse — CAP.: KW 5 H.P.

VOLTS 220 AMPS. 12.7 SPEED 1700 CYCLES 60 POLES PHASES 3

CLASS TYPE CCR FORM TYPE WINDING 2 Star

NO: SPEC. SERIAL COILS 24 SLOTS COM. BARS

WIRE: NO 16 INSUL IN HAND 2 TURNS PER COIL 17 LBS. 36

PITCH: FRONT BACK 1-12 COM. COM. LEAD BARS

STYLE COIL CEN. TO CEN. COIL FORM 10 3/4 ROTOR

START COILS: NO SIZE WIRE INSUL TURNS

ARM IRON: LENGTH 2 DIAM 8 3/4 DEPTH SLOTS: WIDTH DEPTH

ROTOR IRON: LENGTH DIAM DEPTH SLOTS: WIDTH DEPTH

REMARKS:

NOTE—USE BACK OF CARD FOR ADDITIONAL DETAILS ON INSULATION AND COIL FORMS

Winding Stator of Single-Phase Compensated Series Motor

A WINDING for a single-phase, compensated series motor which we put in a stator some time ago should be of interest to readers of INDUSTRIAL ENGINEER. This method of winding allowed the use of form-wound coils all of the same dimensions but some of the coils had twice as many turns as the others. Another unusual feature of the stator was that some of the teeth were wider than others.

The stator had thirty slots and

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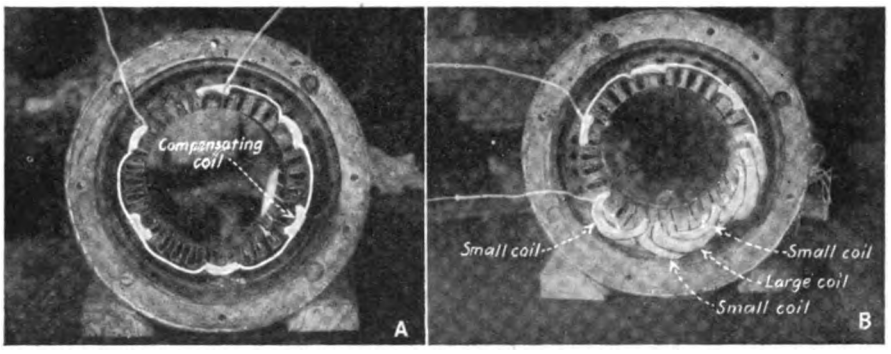


Fig. 1—Compensating and main winding of series, single-phase stator.

At A the compensating winding is shown in place. The six compensating coils are placed around the six large teeth. At B is shown part of the main winding. This consists of eighteen coils, six of the coils being twice as large as the remaining coils. Note how the upper side of the first main coil is held in place during winding by several wedges placed over it in the slot.

twenty-four coils. There were eighteen main coils and six compensating coils. Every fifth tooth had twice the area of the others, as shown in Fig. 1. The compensating coils were wound around these six large teeth. The coils were wound by hand, every alternate coil being wound in an opposite direction, as shown in *E* of Fig 2. The wire was not cut at the end of each coil but was carried over to the next coil, thus doing away with soldered connections. The first compensating coil started in slot No. 1 and finished in slot No. 2. Then the second coil started in slot No. 6 and finished in No. 7. This was repeated around every large tooth, as in *A* of Fig. 1.

Fig. 1, *B*, shows part of the main winding in place. This winding consisted of eighteen coils and six of the coils had twice as many turns per coil as the remaining twelve coils. This winding was a combination of a winding with two slots per coil (single-layer) and a winding with one slot per coil (double-layer). A study of *B* in Fig. 1 will show that each coil with the larger number of turns completely fills two slots. Each small coil is put in so that one side is in the same slot as one-half of a compensating coil; the other side overlaps another small coil. These small coils in turn are made to overlap each other in every sixth slot.

Fig. 2 gives the steps in putting on the main winding. The compensating coils are indicated by the short loops inside the small circle. The first main coil to be put in is a small coil. It is placed in slots No. 1 and No. 4. Slot No. 1 contains also one-half of a compensating coil. These two coil halves completely fill slot No. 1. The second main coil is a large coil and is put in slots No. 30 and No. 3, completely filling these slots. The third main coil (a small one) is put in slots No. 29 and No. 2. Slot No. 2 contains one-half of a compensating coil; therefore it is filled when the third main coil has been put in.

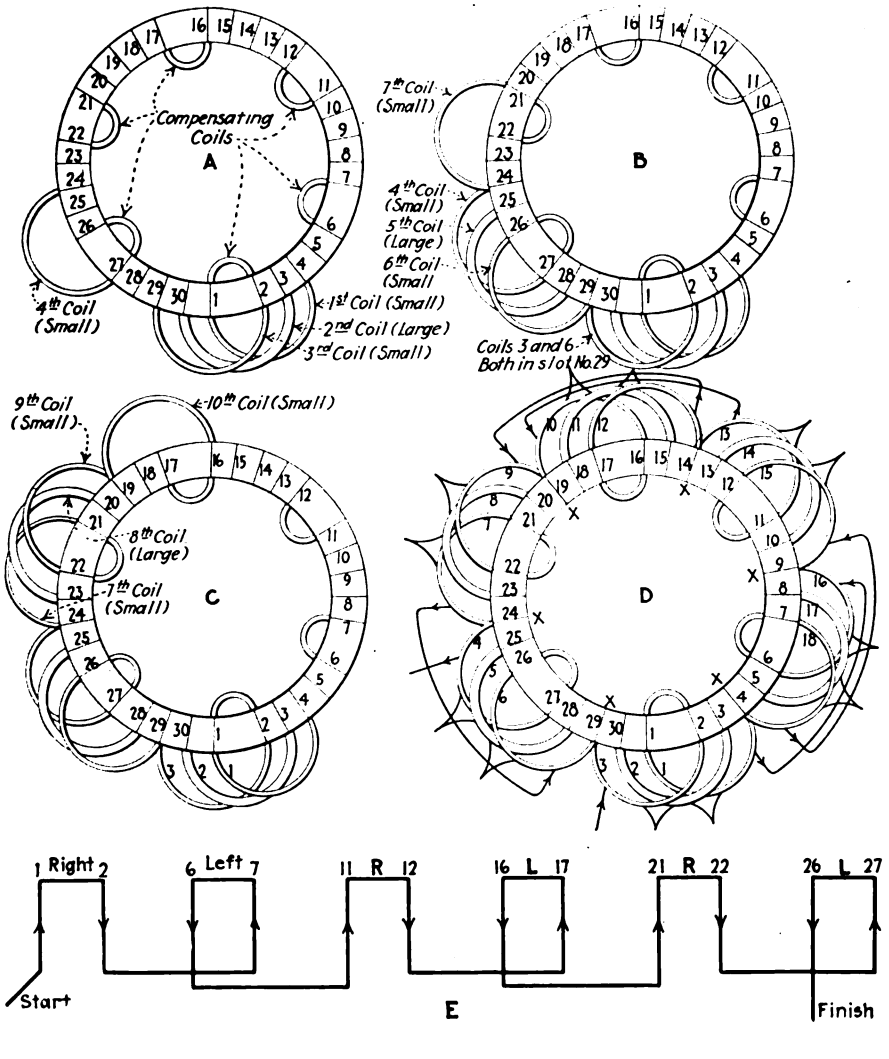
The fourth main coil is put in slots No. 24 and No. 27. This is a small coil and fills up slot No. 27 which already contains one side of a compensating coil.

In *B* of Fig. 2 is a continuation of the winding. The fifth coil is a large one and is put in slots No. 25 and No. 28 working in the opposite direction to the first group. Coil No. 6 is put in slots No. 26 and No. 29. Slot 26 also contains one side of a compensating coil. Slot 29 already holds one side of coil No. 3; therefore coils No. 3 and No. 6 overlap each other in slot No. 29 and fill this slot.

Coil No. 7 is started in slots No. 21 and No. 24 filling both slots, as slot No. 21 holds one side of a compensating coil and slot No. 24 contains one side of coil No. 4, as is shown.

The next drawing, *C*, shows the third group in place and the start of the fourth pole group. At *D* are seen all the coils in place with the groups connected. Note that coil No. 18 overlaps coil No. 1 in slot No. 4; also that twelve small coils fill eighteen slots. The winding is so distributed that these small coils overlap each other at six points and in twelve other slots they are put on top of the compensating coils. The six large coils fill the twelve slots.

Fig. 2—Steps in winding single-phase stator of series motor.



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Bill of Material for Armature Winding Rack

Part No. See Drawing	Description	Number Required	Part No. See Drawing	Description	Number Required
1	Armature shaft roller.	4	14	1-in. x 13-in. pipe nipple	4
2	Armature shaft roller casting	2	15	1¼-in. x 18-in. pipe..	1
3	Roller pin	4	16	1¼-in. x 18-in. iron plug. Turn to fit inside 1¼-in. pipe....	1
4	Washer for roller pin No. 3	4	17	½-in. x 1-in. set screw	1
5	Clamp for wire-tension device rod	2	18	1-in. x 10¾-in. nipple	4
6	"U"-bolt for clamp No. 5	2	19	Standard 1-in. pipe union	2
7	1¼-in. x 12-in. pipe-support for casting No. 2	2	20	Standard 1-in. tee....	4
8	⅜-in. x 36-in. pipe to carry wire-tension device	1	21	Standard 1-in. pipe plug. See No. 22....	4
9	Standard 1¼-in. tee..	2	22	Caster plate, dimensions determined by type of caster. Punch and weld to head of plug No. 21.	4
10	Standard 1¼-in. close nipple	2	23	Swivel caster	4
11	Standard 1-in. tee with 1¼-in. outlet to be tapped for ⅜-in. eye bolt as shown.....	2	24	Standard ⅜-in. x ½-in. flat-head set screw.	4
12	Standard 1-in. close nipple	4	25	⅜-in. x 6-in. eye bolt to carry ⅜-in. pipe for wire reel.....	2
13	Standard 1-in. 45-deg. ell	8	26	⅜-in. x 36-in. pipe to carry wire reel.....	1

The main coils were all wound on the same mold, the only difference being in the number of turns per coil. In the original winding the three coils per group were wound on what is known as a gang mold. This is a mold with three center pieces and with thin barriers between. The three coils are wound without cutting the wire. From three coils only two leads are brought out, start and finish, which does away with twelve stub connections. However, when only one motor is to be rewound the extra time required to make a gang mold is much greater than that required to stub up the groups.

The armature of the motor was wound similar to any standard direct-current wave-wound armature.

Detroit, Michigan. A. C. ROE.

Strong and Handy Armature-Winding Rack Made From Pipe and Fittings

AN ARMATURE winding and banding rack which the writer built from standard pipe, fittings and nipples, is shown in the accompanying drawing. This rack was made from 1-in. and 1¼-in. pipe. The armature shaft is carried on two pairs of rollers, each roller being 3¼ in. in diameter. Four casters are inserted in the base of the rack so that it can be moved about readily. At the lower part of the rack there is a ⅜-in. pipe which hangs in two eye-bolts to support the wire reels. In the upper part is another ⅜-in. pipe for supporting the device for putting tension upon the wire in case the armature is being banded.

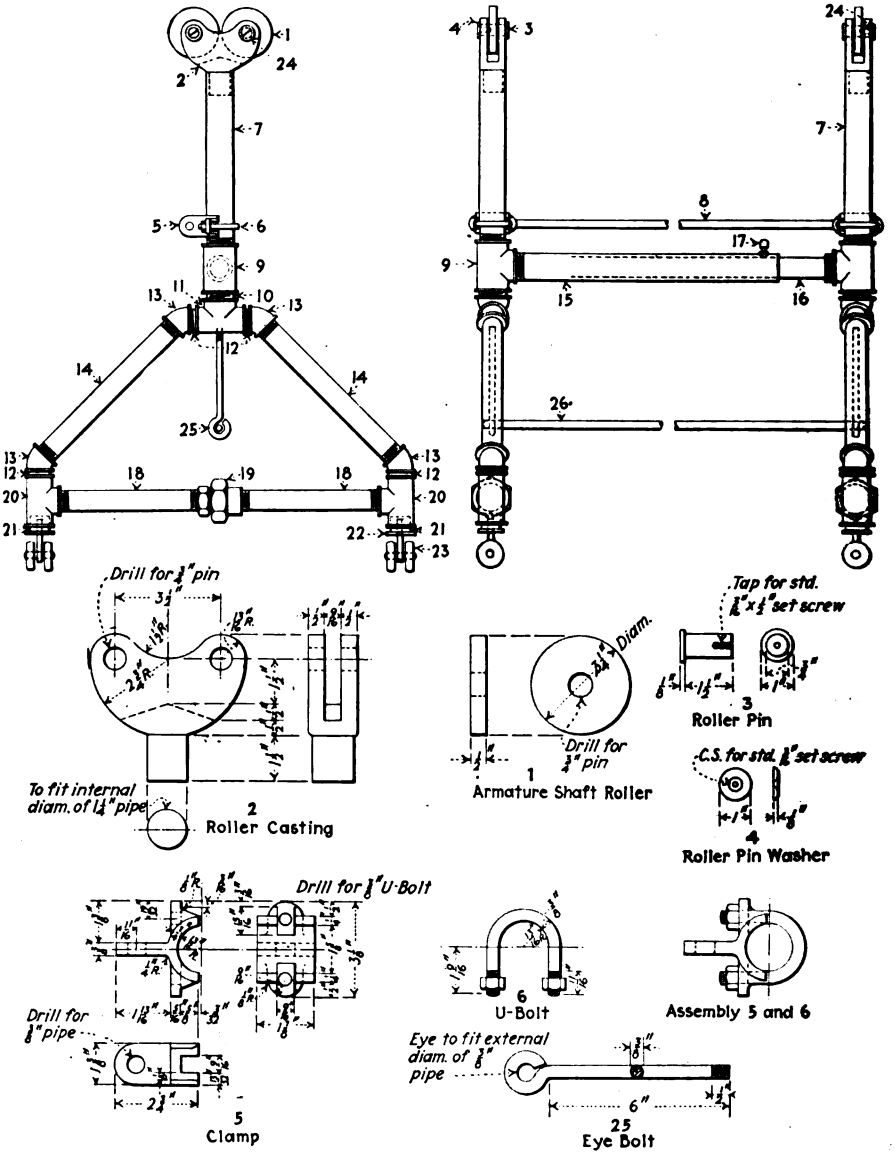
In the construction of this rack there are a few castings and other parts which have to be made. The castings consist of two pivoted bearings for holding the rollers and two clamps for holding the pipe which supports the tension device. Besides this, there are roller pins, the two eye-bolts for supporting the pipe which holds the wire reel and two U-bolts.

It is advisable to make the rollers of copper, brass or fiber so that they will not scratch the shaft. These rollers are 3¼ in. in diameter by ½ in. thick and are drilled for a ¾-in. pin.

A complete list of the bill of material is shown in the accompanying table and the drawings give the details of the special parts which have to be made, with two views of the assembled rack. JOHN W. HOBART.

New York, Ontario & Western R. R., Middletown, N. Y.

This armature rack was made almost entirely from standard pipe and pipe fittings.



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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

A Few Examples of Applications of Lifting Magnets in Industrial Works Which Suggest Ideas Usable in Other Plants

IN DETERMINING whether a lifting magnet will be economical and if so, how much could be paid for it, a rough estimate may be based upon the fact that $100 worth of lifting magnet will do as much work handling iron and steel as could be expected from one strong man. In other words, a $1,600 magnet can do the work of sixteen men, and may be worked overtime with but little additional expense. In addition the total cost of owning, upkeep and power for a magnet is about 10 cents per day per $100 of cost, or one-tenth of 1 per cent per day. On a $1,600 magnet this would approximate $1.60 per day in comparison to the labor cost of sixteen men. This total cost includes interest, depreciation, upkeep and cost of current but does not include any labor costs for the operator. The operator is required for the crane or hoist and no additional help is necessary because of the magnet. Usually less help is required. With these two statements as a basis, it becomes easy to determine whether it will pay to use a lifting magnet for any given job. Ordinarily a magnet may be considered as simply an additional tool added to already existing equipment such as a crane or hoist. Other tools for cranes or hoists are hooks, chains, buckets and similar devices for grabbing or lifting.

Experience has shown that it is not always necessary to handle large quantities of material before a magnet becomes economical. For example, in one of our largest industrial plants rivets are made and conveyed to a boot behind a long annealing furnace. A 10-in round magnet is automatically lowered into this boot and hoisted. When down it is energized and picks up about 25 to 40 lb. of rivets. When it reaches the top of its travel it is automatically de-energized and drops the rivets into a chute. From this they go into the annealing furnace a few at a time without piling up. This automatic operation saves the labor of a man on each turn. It is difficult to get and keep men on hot, disagreeable jobs such as this.

The use of a magnet for piling and unpiling or for loading or unloading iron and steel is probably one of the most common of its industrial applications. For example, at *A* a magnet weighing about 500 lb. handles two small steel ingots at a lift at the Sanderson plant of the Crucible Steel Company. This magnet not only reduced the amount of yard labor required but enabled the ingots to be piled closer and higher as no space need be left for chains. Also, as no chains are required, handling is much quicker and safer.

The 40-in. round magnet shown at *B*, unloads at a lift three 2,000-lb. 8-in. by 8-in. billets. This is only an occasional job, however, as the regular work of this magnet is to load a car of plate scrap each week. Although this is not a heavy task it actually saves about $35 per week or approximately the total cost of the magnet per year, and does a job otherwise hard to take care of as it was too infrequent to keep a gang of men just for this work, and so caused considerable labor turnover. The 40-in. magnet shown in *C* also handles billets in the yard of the Pittsburgh Steel Forge Company. Here it not only saves labor cost but increases the capacity of the yard by higher and closer piling. Since this photograph was made the magnet installation has been duplicated.

For handling long material which would be difficult to balance from a single magnet a spreader-beam with magnets at each end is frequently used. For example, in *D* two special rectangular magnets are shown lifting thirteen 90-lb. rails 40 ft. long, or a total weight of 15,500 lb. These magnets are two of nine used in the rail mill of the Inland Steel Company at Indiana Harbor, Ind.

Steel Pipe Handled per Lift By Two 20-in. Round Magnets (E) on Spreader Bar

No. of Pipes Per Lift	Diameter Inches	Length In Feet	Weight Each, Lb.	Total Weight
1	12	20	900	900
1	10	20	823	823
2	8	22	500	1000
2	6	22	422	844
3	5	22	326	978
4	4	22	239	956
6	3	22	168	1008
7	2½	22	128	896
4 Bundles of 3 Pipes	1½	22	60	720
4 Bundles of 3 Pipes	1¼	22	50	600
4 Bundles of 6 Pipes	1	22	37	888
4 Bundles of 12 Pipes	½	22	18.7	895

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This particular magnet installation is distinctive because of its low headroom, the relatively light weight, and because of the design which eliminates any chance of the long rails working loose while being lifted. Such work as this could not be done economically in any other way.

Several pipe warehouses use magnet installations similar to that shown at *E* for unloading, reloading and for general handling of pipe into and out of the warehouse. In this particular installation two 20-in. round magnets are attached to a spreader beam and spaced about 8 ft. apart. They are used to handle a wide variety of sizes of steel pipe with an average lift of about 900 lb. What this magnet actually lifts at the Chicago warehouse of Kelly and Jones Company is shown in the accompanying table. Here it is noted that the smaller sizes of pipe are handled in bundles, instead of as individual pipes. The big advantages in this installation lie in the elimination of labor, the reduction of accidents and the doubling or trebling, or even more of an increase in the capacity of warehouse space by being able to pile closer and higher.

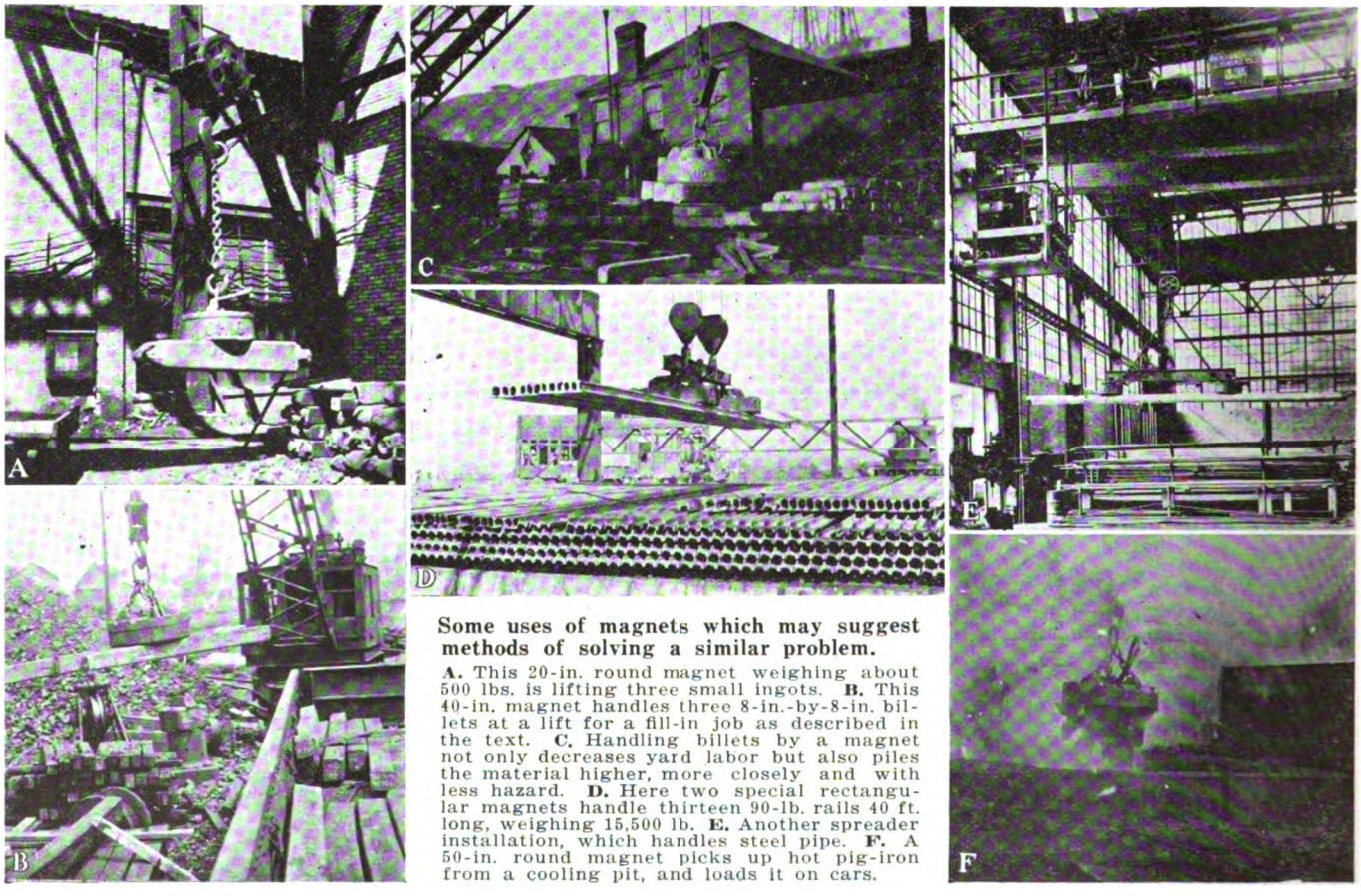
A peculiar installation of a magnet is shown in illustration *F*. Here the magnet is almost obscured by the steam rising from boiling water from which it has just lifted a load of hot pig iron. Two casting machines discharge red hot pig iron into this pit, where it is sprayed with cold water. The magnet, however, reaches down and lifts the pigs out and loads them on cars long before they have cooled. This is a job which it would be impossible to do by hand. This magnet, however, did this work for over three years. However, because the scale which forms on the pig blocked the sewer, another method of cooling and loading the pig iron was installed and the magnet has since been transferred to other work.

Another interesting application consists of a small magnet on a rotating arm mounted so that when it is in its low position the magnet is energized and touches the surface of a galvanizing trough where it picks up a load of pipe fittings. The excess spelter drains off as the arm rotates further. The current is controlled by a drum switch on the same shaft and when this magnet reaches the horizontal position current is cut off and the load of galvanized fittings is dumped into a waiting barrow. This application not only saves labor cost but eliminates a hard job which was very injurious to the workmen. In a somewhat similar application in another plant two magnets on a spreader beam pick up steel angles which have just been galvanized and lower them into a trough of water to cool and wash away any excess of the ammonium chloride flux.

Perhaps the most unusual application of any of these is that of a magnet with a special lead support which is now being built for the Trumbull Steel Company of Warren, Ohio. This is to be used solely to recover coils of strip steel which occasionally fall off the racks in the acid tanks. The acid is 6 ft. deep and it would be very difficult to get these coils out in any other way. This is an interesting use of a magnet.

These are only a few of many examples which could be given to illustrate the saving in labor or time, the reduction in accident hazard and other advantages which result from the use of a magnet in industrial works. Because of the big savings possible at low cost, it is seldom necessary to find continuous work for a magnet to make its installation economical. In one case mentioned here one job a week repaid the cost of installation. F. W. JESSOP.

The Ohio Electric & Controller Co., Cleveland, Ohio.



Some uses of magnets which may suggest methods of solving a similar problem.

A. This 20-in. round magnet weighing about 500 lbs. is lifting three small ingots. **B.** This 40-in. magnet handles three 8-in.-by-8-in. billets at a lift for a fill-in job as described in the text. **C.** Handling billets by a magnet not only decreases yard labor but also piles the material higher, more closely and with less hazard. **D.** Here two special rectangular magnets handle thirteen 90-lb. rails 40 ft. long, weighing 15,500 lb. **E.** Another spreader installation, which handles steel pipe. **F.** A 50-in. round magnet picks up hot pig-iron from a cooling pit, and loads it on cars.

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Trade Literature *You Should Know About*

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

The Master Builders Company, Cleveland, Ohio.—A small folder describes "Quickfix," a new compound for repairing concrete floors, which, it is claimed, will produce a patch of flint-like hardness in 48 hr. It is particularly adapted to repairing aisles and runways worn by trucks or trailers in industrial plants, with but little interference with traffic. In cases of emergency patches can be laid Saturday noon and the floor will be ready for use Monday morning. It is claimed that floors can be repaired at a cost of less than 2 cents per sq. ft. for material.

The Texas Company, 17 Battery Place, New York City—The May issue of the magazine, "Lubrication," a technical publication which is devoted to the selection and use of lubricants, and distributed by The Texas Company, devotes considerable space to the lubrication of knitting and textile printing machinery. Each issue covers the lubrication of some special type of machinery.

Terminal Engineering Company, Inc., 17 West Forty-Fourth Street, New York City—Circulars describe the TEC elevating platform electric industrial trucks for urban haulage. The particular feature of these trucks is that they have a larger platform and higher wheels than the ordinary trucks. Also, this enables them to be used either within a plant or on the street for hauling some distance between buildings or plants. These trucks are 4-wheel drive and use a special platform which may be loaded separately and picked up by power and carried by the truck. A wide variety of applications is illustrated.

The Electrical Alloy Company, Morristown, N. J.—Catalog 10, Bulletin 2, describes "Calido," a nickel-chromium resistance wire for electrical heating devices and high resistance units, by means of a number of charts and tables. One page is given over to a list of the various bulletins issued by this company on special alloys.

Lewellen Manufacturing Company, Columbus, Ind.—Catalog 15 describes the Lewellen variable speed transmissions. These consist of a special belt passing over tapering pulleys the diameter of which may be varied and so change the speed ratio. These are made either in ball-bearing types for continuous or heavy operation, or in self-oiling types where operation is intermittent or occupies only a short period within the year, as in the canning industry. The illustrations show the construction and assembly as well as a description of a number of installations. Several pages of necessary engineering information and data are included.

Superior Flake Graphite Company, 76 West Monroe Street, Chicago, Ill.—A series of small folders describe the various types and uses of "Superflake" graphite for crucibles, lubrication, boiler compounds, and various other miscellaneous applications.

Jewell Belting Company, Hartford, Conn.—A four-page folder describes the use and application of Jewell liquid belt dressing to leather belts.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—Bulletin 1003-A describes the construction and operation of the Type Q brakes for use in stopping and holding rotating machinery. Probably the most general application is on cranes and other types of hoisting machinery. These brakes are made in two general styles with reference to the method of operation. For example, one style is magnetically operated while the other is mechanically operated.

(*This table is continued from page 402*)

SYMPTOM	TROUBLE	CAUSE	REMEDY
		A^{11} Insulation roasted by constant overload.	A^{11} Same as A^2.
	B Short circuit between high and low-tension windings.	*B* Any of the causes in trouble A.	*B* Same as A^2.
	C Ground between low-voltage winding and core.	*C* Lightning discharge, insulation break-down due to line surges or shifting of coils.	*C* Same as A^8.
	D Short circuit on terminal board.	*D* Moisture in oil.	*D* Remove terminal board, bake and revarnish and pass oil through a filter press.
	E Short circuit between high or low-tension bushings.	*E* Bushings broken or cracked.	*E* Replace bushings.
	F Improper division of load.	*F* Parallel operation of transformers with different characteristics.	*F* Transformers which are to be paralleled should have the same characteristics. If one bank has a high reactance and it is desired to parallel it with a bank having a low or no reactance, reactance coils should be inserted between the two banks.
	G Low-voltage windings punctured.	*G* Ground on high-voltage line of a star-delta system. A ground on such a system imposes delta voltage on the star winding, or star voltage x $\sqrt{3}$, and the bank cannot be operated.	*G* Remove ground before trying to operate. If system is properly protected the circuit breakers will open and cannot be again closed.
5 Unequal heating in bank of star-connected transformers with the neutral grounded.	Ground on one phase.	Defective insulation in transformer or ground on line due to defective insulators, dead birds, kite strings or other obstructions.	Disconnect the bank from service immediately, since a trouble of this kind short circuits the bank. Note: The insulation between the windings and core is limited to a voltage of 57.7% of the line voltage, with a star connection, and if one phase or line is grounded, the voltage between the ground and the remaining two circuits is increased to as high as full line voltage in some cases.
6 Unequal heating in bank of transformers, connected star primary, delta secondary, with grounded neutral on high-voltage side.	Ground on one of the primary phases.	Same as above	Disconnect the bank until the trouble is removed as the bank cannot be operated on open delta.
7 Voltage not the same in all phases of a three-phase bank of transformers.	*A* Ground on one phase of a bank connected star-delta.	*A* Broken insulator on line, line in contact with some obstruction leading to ground, defective insulation in transformer, bushing punctured and terminal grounded.	Cut out the bank on which the defect occurs and remedy by removing cause of ground, replace insulators, bushings or section of winding causing trouble.
	B One transformer bucking the other two.	*B* One transformer connected so that its polarity is opposite that of the others. If not cleared soon one or more of the transformers may burn out.	Change the polarity of the transformer causing the trouble. To test polarity, connect the primaries in parallel and the secondaries in parallel, with a fuse in series with the secondary windings. If transformers are of opposite polarity, the fuse will short circuit one transformer on the other and will consequently blow the fuse. If the fuse blows, interchange the leads and test until the fuse does not blow, when the polarities will be the same.
8 Voltage too low	Wrong ratio.	Leads not connected to proper taps.	Raise the taps to one higher or until voltage is correct.
9 Voltage too high.	Wrong ratio.	*A* Same as above.	*A* Lower taps until voltage is correct.
		B Transformers paralleled that have different ratios.	*B* Change ratios until all transformers are same or if this cannot be done replace transformers.

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Super-Safety Electric Switch Company, 1200 West One Hundred Fourth Street, Chicago, Ill.—A circular describes the "Super-Safety Switch" which is claimed to be absolutely safe, as no live parts are exposed even with the door open. Also, fuses are automatically thrown into and out of circuit with the throw of the handle, and when dead are exposed to view, which eliminates the possibility of touching live fuse terminals when it is necessary to renew a fuse. Numerous other claims of advantages of this switch are given.

Angle Steel Tool Company, Plainwell, Mich.—A folder describes a number of the various types and styles of steel stools and chairs for factory, office, and other industrial and business purposes. These are made of angle steel with hardwood seats.

Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill.—A folder describes and illustrates the use of Janette special motors of 1/20 to ¼ hp. on Addressograph machines.

The Robbins and Myers Company, Springfield, Ohio—Bulletin 135 gives the details of the new Type L polyphase motor which is being made in a large range of sizes. Among the many features claimed are a new method of ventilation which enables the motor parts to be constantly bathed with cool air, a higher power factor, improved starting torque, dust-proof bearings, reversible terminal box with cover removable, and a decrease in size and weight with added rigidity and strength.

Russell Manufacturing Company, 814 Bath Avenue, Niagara Falls, N. Y.—This company is distributing a vest pocket memorandum book which contains, in addition to the memorandum features, some of the advantages claimed for the Trigger-Lock reversible controller fingers, as well as an explanation of how to install them.

A. W. Cadman Manufacturing Company, Pittsburgh, Pa.—Engineering Bulletin M-1 entitled "Cadman Metals" covers a digest of sixty years' pioneer work in the development of bearing metals. After discussing the requirements of a bearing metal this bulletin takes up various properties of the Cadman metals, such as hardness and compressive strength, relative wear, coefficient of friction, ability to hold an oil film under adverse conditions, plasticity, ability to carry the load at normal temperatures, ease of pouring and handling, uniformity, tensile strength and bonding properties and use in die casting.

Bussmann Manufacturing Company, St. Louis, Mo.—An attractive booklet entitled, "Buss Renewable Fuses," illustrates and mentions the principal points and advantages claimed for the Buss fuse. The carefully prepared illustrations in two colors show these points almost as well as the printed descriptions.

The Ohio Electric and Controller Company, Cleveland, Ohio—A small folder describes Ohio motors for shop equipment. Particular attention is given to the use of this motor with the Burke bench drill.

Crown Die and Tool Company, 555 West Monroe Street, Chicago, Ill.—A 24-page booklet, No. 1122, describes the Crown easy cutting pipe dies and labor-saving pipe tools, including pipe vises, portable vise stand, stocks, reamers, cutters and special pipe or conduit bending equipment.

H. Gerstner & Sons, Dayton, Ohio—Catalog No. 3 entitled, "High Grade Tool Cases and Chests," describes a variety of this equipment for the up-to-date mechanic, toolmaker, machinist, and other skilled industrial workers. Some of these cases are portable, while others are larger and heavier for bench use.

New Uses of Electric Steam Boilers

(*Continued from page 405*)

go to waste. These mills need a certain amount of steam during the winter and some of them during the entire year for process work. In such cases the additional power for producing this heating and process steam electrically can be obtained at a small cost thus making the mill's operation practically independent of coal.

There are a number of plants and institutions where a small quantity of steam or hot water is required only at intervals. If a coal-fired boiler is used, it must be kept banked and in service ready to furnish this steam. The greater part of the fuel is consumed while the boilers are standing idle. In such cases electric power can often be purchased for the production of steam or hot water at less cost than it can be made with coal.

It is also true that in some cases the demand charges are too high to permit the use of electric boilers, but a careful comparison of the two methods of making steam should be made.

Twenty-Three Installations of Electric Boilers in Industrial Plants

Company	Number Boilers Installed	Rating of Each Boiler	
		Kw.	Boiler Hp.
Metropolitan District Water Commission, Clinton, Mass.	1	30 to 40	3 to 4
Frank & Lochner, Buffalo, N. Y.	1	100	10
Purity Wool Preparing Co., Peterborough, N. H.	1	130	13
Northern New York Utilities, Inc., Watertown, N. Y.	1	150	15
	1	1,000	100
Millers Falls Paper Co. Millers Falls, Mass.	1	350	35
Cascade Inn, Shawinigan Falls, P. Q., Canada	1	350	35
Niagara Falls (N. Y.) Power Co.	1	18,000	1,800
	1	1,000	100
Canadian Electro Products Co., Shawinigan Falls, P. Q., Canada	2	1,300	130
Montreal Cotton Co., Valleyfield, P. Q., Canada	2	1,500	150
Rochester Gas & Electric Corp., Rochester, N. Y.	1	3,000	300
Ontario Paper Co., Thorold, Ont., Canada	1	3,000	300
Ford Motor Co., Green Island, N. Y.	1	3,200	320
Wayagamack Pulp & Paper Co., Three Rivers, P. Q., Canada	1	5,000	500
Canadian Electro Products Co., Shawinigan Falls, P. Q., Canada	2	5,000	500
Washington Pulp & Paper Co., Port Angeles, Wash.	1	5,000	500
International Paper Co., Niagara Falls, N. Y.	1	6,000	600
U. S. Aluminum Co., Pittsburgh, Pa.	1	5,000 to 7,000	500 to 700
Price Bros. & Co., Kenogami, Canada	1	7,000	700
St. Maurice Lumber Co., Three Rivers, P. Q., Canada	1	12,000	1,200
Oxford Paper Co., Rumford, Me.	1	16,000	1,600
Brown Co., Berlin, N. H.	1	18,000	1,800
Belgian Industrial Co., Ltd., Shawinigan Falls, P. Q., Canada	1	20,000	2,000
Laurentide Co., Grand Mere, P. Q., Canada	2	25,000	2,500

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

September, 1923

McGraw-Hill Co., Inc. Chicago, Ill

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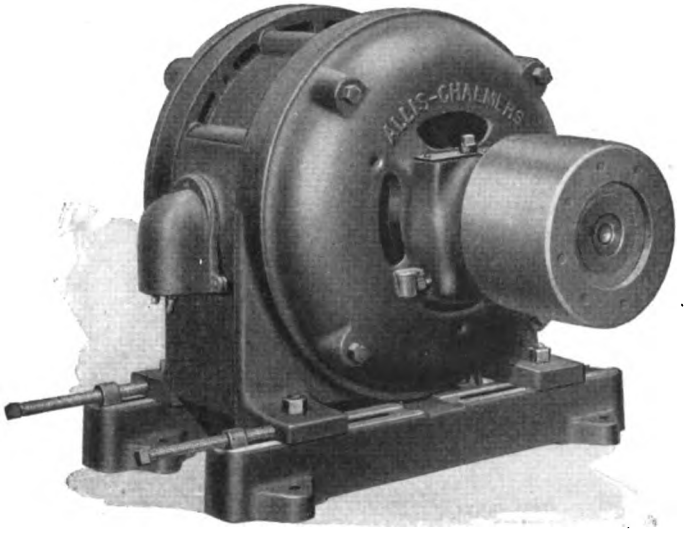
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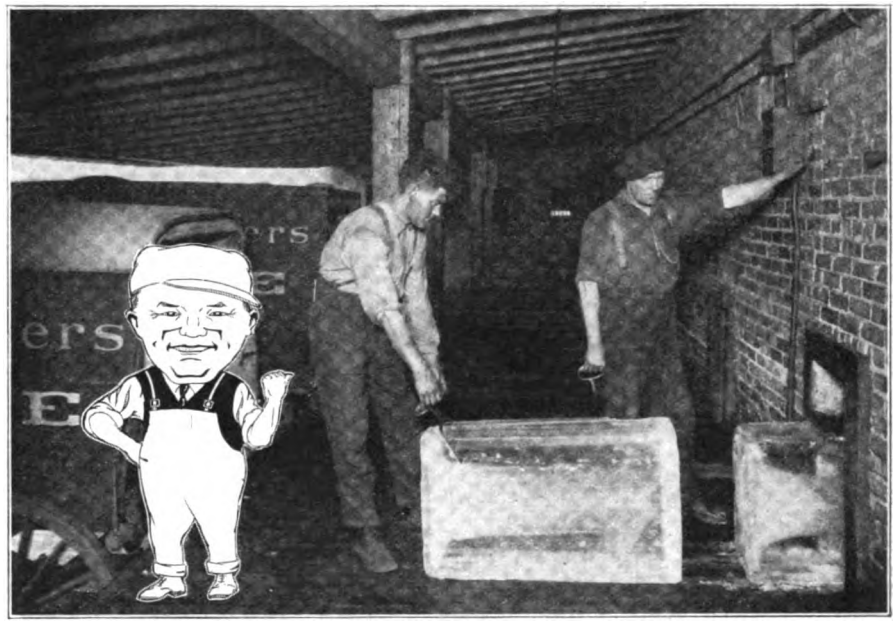
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, September, 1923 *Number 9*

Jerk Up the Handle and Out Comes the Ice—

That Is About All These Icemen Know About Electrical Switches



THERE is one thing about readers of INDUSTRIAL ENGINEER that gives me real satisfaction in working with them and for them. It's their genuine interest in improving ways of doing things to get better results and the pride they take in the results they secure. When they devise methods that get results they talk about them and fight for the principles that they employ until they find something better; then they drop the old and boost for the new. After all this is a mark of bigness in a man whether he be the president of a company or the foreman of a department. Someone has said that "if a man's work is merely work he's in wrong, for any man who does not feel that the results he secures are worth to him about as much as his pay, has the wrong job," and it's about so.

As an illustration of the point I am trying to make, here's a letter from Mr. Leo Winkler of the Consumers Company, Chicago:

DEAR PETE:

In the July number of INDUSTRIAL ENGINEER you ask for comments on the subject of durability of switches in service, and you very pertinently remark upon the fact that actual service is the final test that all apparatus must stand. This point of your remark I must say is well taken.

In your article you quote from a letter received from Mr. J. E. McNeil of the Square D Company regarding the operation of switches to start and stop the three horsepower motors used for raising and lowering the gates at the Austin Boulevard crossing of the Metropolitan West Side Elevated Railway Company. Of course, Pete, this is not your own statement and I don't want to hold you responsible for it. In fact, your own assertion following the quotation would seem to disclaim this responsibility.

The final paragraph of your letter asks for details of a switch installation that has withstood more abuse, so here you are. Incidentally, I will say you have me slightly beaten in point of number of operations but otherwise you haven't.

In September, 1921, there was installed on the loading platform of this ice-making plant a 30-amp., 220-volt, Super-safety switch to control a 10-hp. three-phase motor, which motor operates 160 feet of chain on an ice conveyor which runs the entire length of the ice storage room. Now, in the first place, you will observe that the switch is somewhat overloaded, and in the second place I will observe that it takes the load straight across the line and is not protected by either circuit breakers or limit switches. The average number of operations has been 250 to 500 times a day the year around and the switch is not operated by electricians but by wagon men who back their wagons up to the platform, then step out onto the platform and start the motor, get their loads and drive away, to be followed by others.

There are especial reasons why this switch has withstood the severe duty imposed upon it, but these reasons have to do with the construction of the switch, and I will leave the explanation of them to the makers. This switch is still in service and bids fair to last a long time.

After receiving this letter I went out to see this installation and took the picture shown here. Mr. Winkler has not overstated the satisfactory service from this switch. The fellows who operate it are husky specimens and in a hurry. They have been jerking it in and jerking it out for two years while previously an ordinary knife switch went to the junk pile every three months. Considering the investment and the service, this switch is a real dividend payer.

Practical Pete

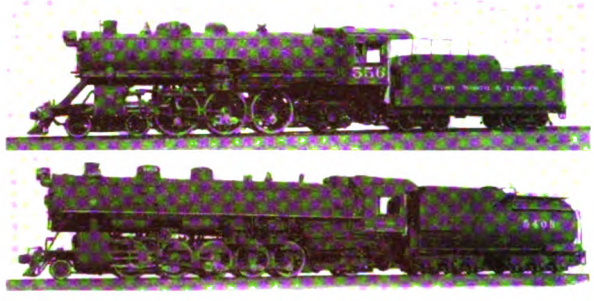
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A Glimpse Into

The Baldwin Locomotive Works

Pioneers in the design and construction of steam locomotives since 1832 and now operating works covering over 600 acres. The ninth of a series devoted to the growth and extent of our basic American industries.

MAINTENANCE and repair of equipment cost the railroads of the United States more than $1,590,000,000 in 1920 and maintenance of way cost over $760,000,000 more. The railroad shops engaged in this work rank second among industries in the number of wage earners employed, with a total of over 484,000 according to the 1919 census figures. Perhaps nothing else, except a race horse or airplane, receives the attention and care given to the modern locomotive. After each trip it is gone over carefully and put in first-class condition for the next run because it *must* not break down in service.



Two heavy locomotives of modern construction.

The upper illustration at the left shows an express passenger locomotive of the "Pacific" type which was developed for hauling heavy passenger trains at comparatively high speed. The lower view represents a modern, oil-burning freight hauler built for the Union Pacific System. The tractive force is obtained through ten drive wheels.

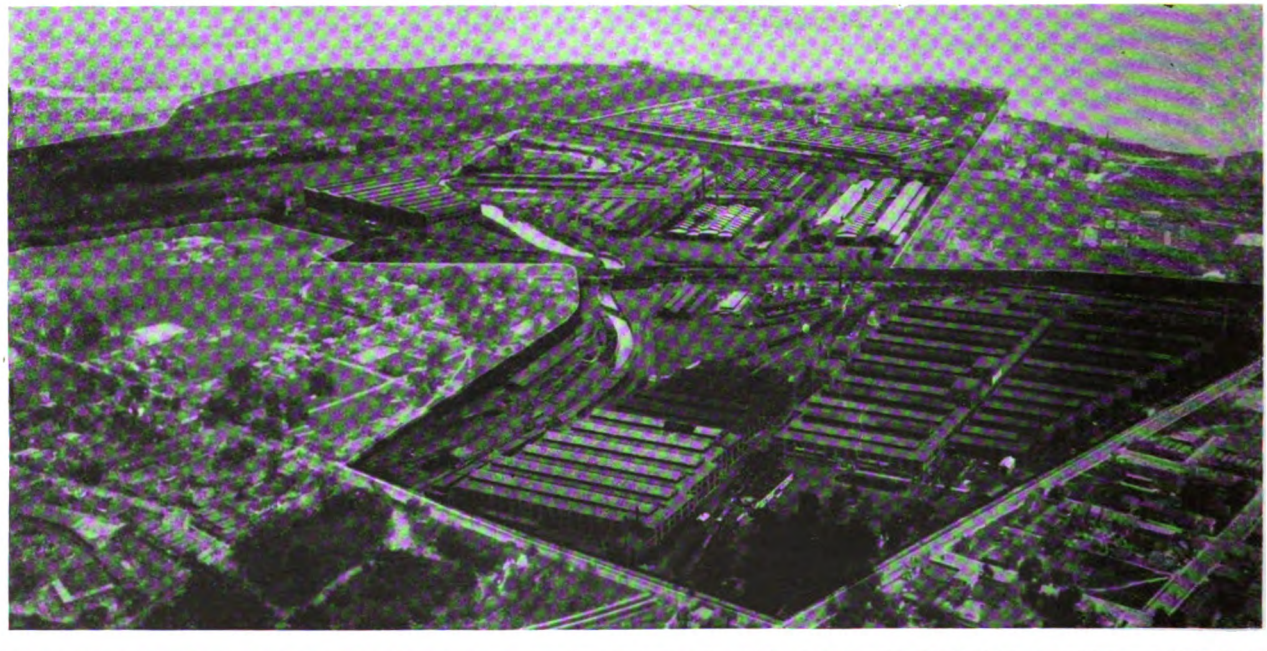
The first locomotives used in the United States were imported from England, but in 1832 Matthias W. Baldwin built "Old Ironsides" to replace horses on a 6-mile line between Philadelphia and Germantown. The difficulties in filling the order can hardly be appreciated today. With only the experience gained in making a miniature locomotive the problem seemed insurmountable. Few mechanics could do the work. Cylinders were bored by a chisel fixed in a block of wood and turned by hand. Mr. Baldwin did much of the work himself, trained the workmen and improvised the necessary tools.

Airplane view of Eddystone plant, The Baldwin Locomotive Works.

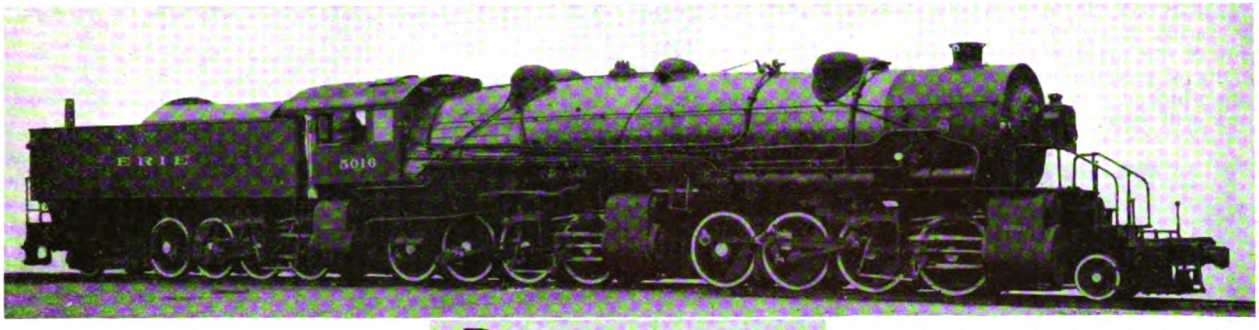
The Eddystone plant occupies 596 acres on the Delaware River, 12 miles below Philadelphia. The offices and principal machine shops are at the original works and occupy 19 acres in the heart of Philadelphia. Originally this plant was designed to give additional erecting facilities but was greatly enlarged during the war for the manufacture of rifles and ammunition, in addition to the construction of many locomotives and gun mountings. In 1918, 3,580 locomotives were built and to maintain this output would require employment of 21,500 men. About 57,400 hp. in motors are installed.

Five locomotives with numerous improvements were built in 1834. By 1838 engines weighing 26,000 lb. were made and Mr. Baldwin declared them to be as large as he ever intended to build. By 1837 over 300 men were employed. In 1848 Mr. Baldwin built an engine which made 80 miles per hour on a short stretch.

Drive wheels offered another difficulty in the early engines. On "Old Ironsides" the wheels were made with heavy cast-iron hubs, wooden spokes and rims, and

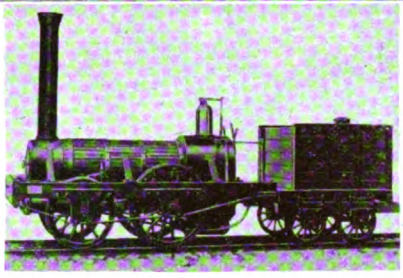


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The first Baldwin locomotive, "Old Ironsides," and one of the largest ever built at the Baldwin plant.

Matthias W. Baldwin, proprietor of a Philadelphia machine shop, built a miniature locomotive for exhibition in a museum in 1830 and in 1831 began the construction of the first of his locomotives for railway service. "Old Ironsides," shown at the right, made its trial run Nov. 23, 1832, over the 6-mile track of the Philadelphia, Germantown & Norristown R. R. Co., and attained a speed of about 28 mi. per hour. The contract price for this locomotive was $4,000. The two driving wheels of "Old Ironsides" were 54 in. in diameter, while the cylinders were 9½ in. in diameter with an 18-in. stroke. It weighed about 5 tons. The Mallet locomotive above weighs 860,000 lb. and was one of three built for special "pusher" service on the Erie Railroad and on a test run hauled 250 loaded cars, 1.7 mi. long and weighing 17,912 tons.



wrought-iron tires. Brass was tried. Later a chilled cast-iron tire was used. Originally, track consisted of an iron strip on a plank.

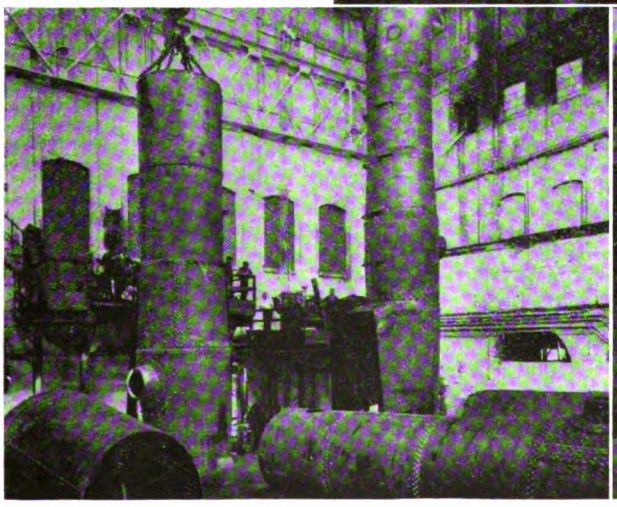
The discovery of the Bessemer process of making steel resulted in the use of steel for rails and tires and later for fireboxes and other parts. The period since has been devoted to improvements and increments in weight and power with special emphasis on more economical generation and use of the steam. During the past ninety years locomotives have increased in weight from 5 tons to over 400 tons. During the war year of 1918 the Baldwin Locomotive Works had its highest production with 3,580 locomotives, many of which were for war service.

Without the railroads, which are one of the largest industries with an annual business of about 6¼ billion dollars in 1920, the entire economic and commercial history of this country and that of the world would have been changed. In 1920 about 235,000 miles of railroad were operated in the United States or about a third of the total mileage in the world. Modern industry and agriculture could not exist without them.

Three steps in the construction and erection of Baldwin locomotives.

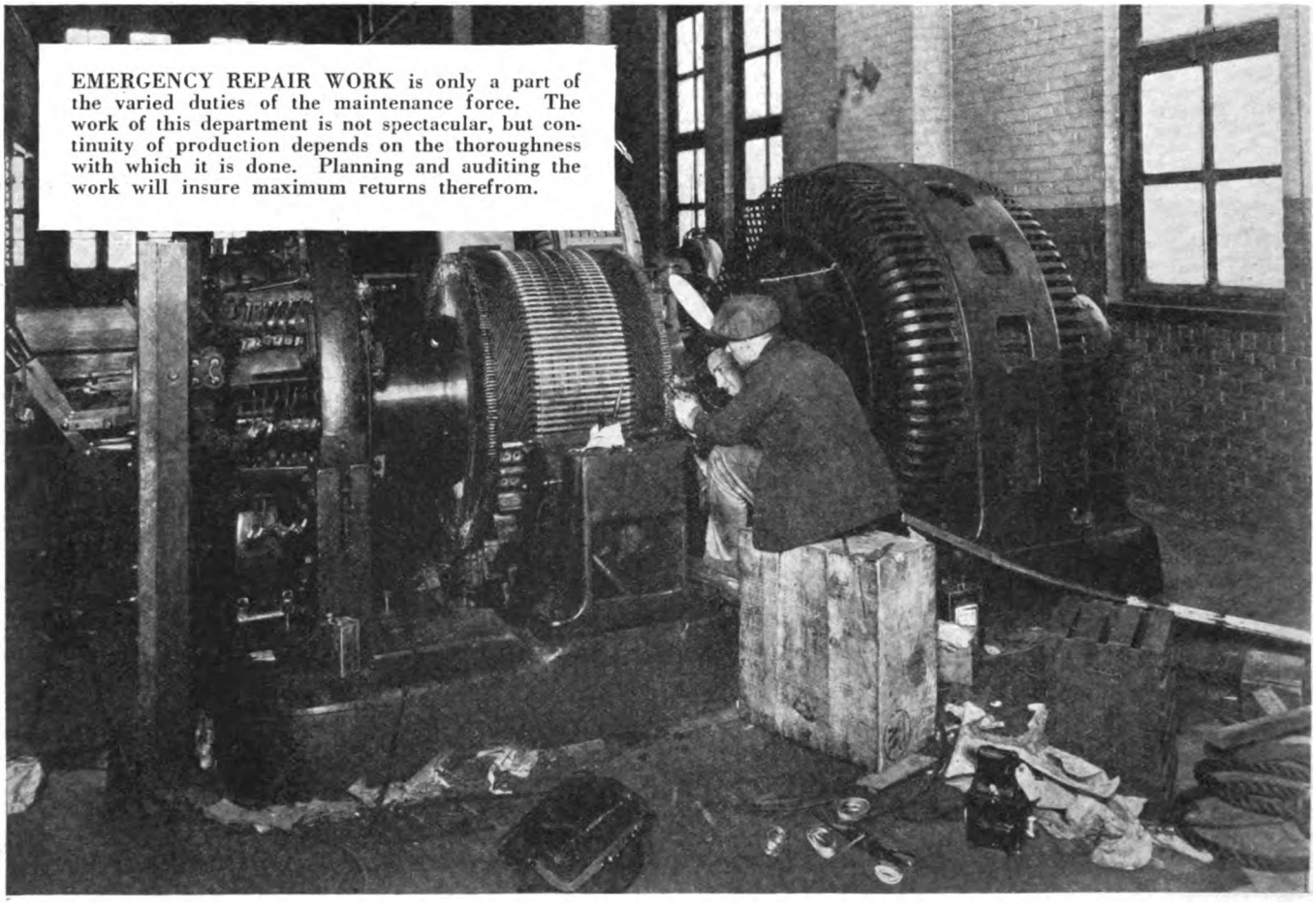
Much of the effectiveness of the locomotive depends upon the design and construction of the boiler. One of the early advantages of American locomotives over those imported from England was that English locomotives operated at 60 lb. pressure while the American locomotives were operated at 120 lbs. At present, many are operated at 200 lb. or over. In the assembly shop, shown at the left, powerful cranes lift an entire locomotive. The lower view at the right shows the casting of a locomotive cylinder in the Eddystone foundry. Cylinders on a compound engine weigh several tons and present one of the big problems in locomotive foundry work. Locomotives require accurate, high-grade machining.







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EMERGENCY REPAIR WORK is only a part of the varied duties of the maintenance force. The work of this department is not spectacular, but continuity of production depends on the thoroughness with which it is done. Planning and auditing the work will insure maximum returns therefrom.

Some of the Ways

Procedure in Maintenance Work Can Be Audited

Before Work Is Started and at the Time the Expenditures Are Being Created

By ARTHUR J. WHITCOMB

Formerly Assistant to Superintendent, The Steel and Tube Company of America

THIS IS the last of three articles that analyze the essential factors of maintenance procedure. It deals particularly with methods that can be used to audit the work done by maintenance men and keep accurate record of equipment in operation. The first article in the January issue took up the handling of repair and replacement materials with details of storing them and distributing charges for materials required to departments using them. The second article in the April issue dealt with the auditing of power service requirements, the charging of power costs to departments and processes using power service, and told what a proper distribution of power costs is and what it is not.

IN THE FIRST article of this series the writer pointed out that information would be presented to show how an audit may be made of the operations of a maintenance department before and at the time the expenditures are being created by that department. In this connection it was also indicated that the methods discussed would include:

(1) A means of auditing the incoming and outgoing electrical material used in making repairs, spare parts, etc. (2) A power service audit; that is, a power distribution. (3) An accounting of the work of the men in the electrical department. (4) An accounting or record of electrical equipment.

Subject No. 1 was presented in the first article, which appeared in the January, 1923, issue. Subject No. 2 was discussed in the April issue. In what follows subjects Nos. 3 and 4 are taken up.

In the first two articles methods were outlined in detail for auditing the incoming and outgoing materials and for accounting for the power used in a plant. This article will deal particularly with the methods of accounting for the work done by the maintenance men. In this connection details will be given for what might be called an "Electrical Department Equipment Ledger."

The electrical department of a large mill or factory can be divided into four main sections, as follows:

1. The planning or engineering section.
2. The construction section.
3. The maintenance section.
4. The repair section.

It is the duty of the engineering section to determine the nature and extent of the changes, improvements or new construction necessary, to specify the materials required, to

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make drawings and give the necessary orders for the installation of same.

The work of this section does not make much of a showing to the casual observer. It is not concrete; yet it is vital, and the successful operation of the completed job is based primarily on the thoroughness with which the men in this section do their work. It is, therefore, difficult to render an accounting or audit of the work of this section. At the Mark Plant of the Steel and Tube Company of America, an attempt is made to do this by the use of the *Progress Sheets*, a copy of which is shown.

A sheet similar to the one shown as Fig. 1 is made for each job. The name of the job is written on the line marked *Subject*. On the line marked *First Notice and Source* the date and origin of the work are given. In the following line are placed the date on which the estimate was made, the number of the estimate and by whom made. A number is given to the job to identify it. This number is placed in the space provided, together with the name of the person issuing it and the date of issue. As soon as approval to go ahead with the job has been received, the date of the approval together with the number of the appropriation covering the cost of the job are entered in their respective spaces. An account number is also given to the job. It is to this number that all material and labor must be charged. It is often necessary to advise some other departments of the approval of the job. A space is provided for the date on which this was done. A space is provided for the date on which the drives were calculated and another for the date on which the layout of the drive was determined. A space is given for the number of the control specification and the name of the man who prepares it. Spaces are provided for the serial or shop numbers of the motors and controls assigned and the date of assignment.

In many cases it is necessary to give the motor data to the machine builder. The date on which this was done is placed in the space provided. On the following line are given the shipping instructions. On the next line is entered any action that it is necessary to take in regard to the mechanical parts. When the cards of the accounts, that is, the subdivisions of the account numbers are issued, the date is entered on the following line.

There is also a place for entering the description and numbers of the various drawings necessary for the job, together with a record of their progress, such as the dates of starting, finishing, checking and issue.

Below the above tabulations is space for a tabulation of the material required. To the right of the description of the material are the columns for recording the requisition number, the date of ordering, the date on which the requisition was approved, the date on which delivery of the material is promised, and the date on which it is received.

A shop order is necessary for the installation of the work. Spaces are provided for the date of placing the shop order, its number, the date of the acknowledgment of the order by the section doing the work, the date on which completion of the work is promised and the date of actual completion of the work. There must be

Fig. 1.—This form of Progress Sheet provides complete information on machine installations that is needed when an audit is being made of the work done.

SUBJECT: 10'-20' Jacket Forming Machine

FIRST NOTICE AND SOURCE 6/10/21 H. C. White

ESTIMATE MADE 6/15/21 NO 142 SUBMITTED BY O.C.C.

JOB NO 157 ISSUED BY O.C.C DATE 6/15/21

APPROVAL RECD 7/1/21 APPROP NO 189 ACCOUNT NO 212

ADVISED R.R.S ✓ ISSUED ESTIMATE 7/1/21

DRIVES CALCULATED 7/6/21 DRIVE DETERMINED 7/7/21

CONTROL SPEC NO 147 PREPARED R.M.V.

MOTORS ASSIGNED Shop No. M-256

CONTROL ASSIGNED Shop No. P-294

MOTOR DATA TO MACHINE BUILDER 7/8/21

SHIPPING INSTRUCTIONS 7/8/21

MECHANICAL PARTS ✓

CARDS OF ACCOUNTS ISSUED 7/15/21

DRAWINGS

DESCRIPTION	NUMBER	START	FIN.	E.E. CHECK	ISSUED
Location and Foundation	506-201	7/8	7/12	7/15/21	7/22
Wiring Diagram	506-210	7/10	7/15	7/16/21	7/25

MATERIAL REQUISITIONED

DESCRIPTION	REQ. NO	DATE	ORD NO	DATE	REC'SD	PROM.	RECD.
Motor	R-18921	7/10/21	M-2647	7/21	7/21	9/1/21	10/15/21
Control	R-18922	7/10/21	M-2648	7/21	7/21	9/1/21	10/20/21

SHOP ORDER PLACED 10/1/21 NO 214001 ACK. 10/7/21 PROM. 10/15/21 COMPD. 10/21/21

SPARE PART PROTECTION CHECKED 10/1/21

INSTALLATION CHECKED 10/21/21 TESTED 10/21/21

APPARATUS CHARGED OUT 10/25/21

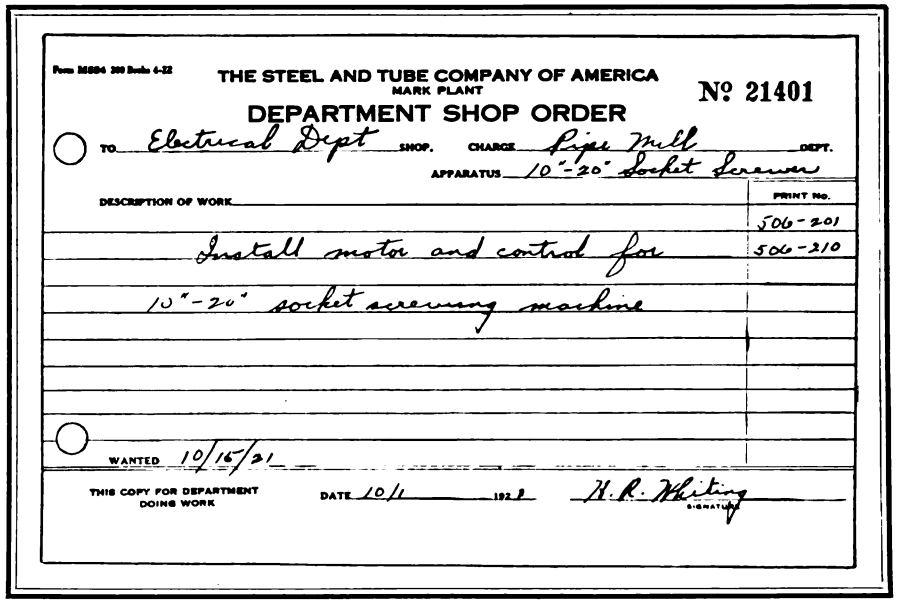
ACCOUNT CLOSED 11/1/21 COST FIGURES RECD 11/16/21

REMARKS:

PROGRESS SHEET NO. 141

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Fig. 2.—This department shop order shows authority for doing the work. Five copies are made out.



THE STEEL AND TUBE COMPANY OF AMERICA
MARK PLANT

DEPARTMENT SHOP ORDER

No 21401

TO Electrical Dept SHOP. CHARGE Pipe Mill DEPT.

APPARATUS 10"-20" Socket Screwer

DESCRIPTION OF WORK — PRINT No.

Install motor and control for — 506-201
10"-20" socket screwing machine — 506-210

WANTED 10/15/21

THIS COPY FOR DEPARTMENT DOING WORK

DATE 10/1 1921 H. R. Whiting SIGNATURE

spare parts for the pieces liable to wear or breakage and so, when the necessary parts are determined and requisitioned, the date when this was done is placed in the space provided.

After the installation is completed it is necessary to check and test the apparatus. When this is completed the dates are marked in the places provided.

The date on which the apparatus is charged out is placed in its proper space; also the date of closing the account and of receiving cost figures.

This sheet is given a number and the number is placed in an index to the volume in which these sheets are filed in numerical order.

Inspection of this sheet will show that primarily it is a record of the progress of the job. It also prevents the engineering section from overlooking or forgetting part of their work. While very few actual details and specifications of the job are given, yet it is a complete index to all the information concerning a job. It is in this manner that the sheet is most important. Finally the sheet or the volume of sheets which is known as the *Progress Book* is an actual account or audit of the work of the engineering section.

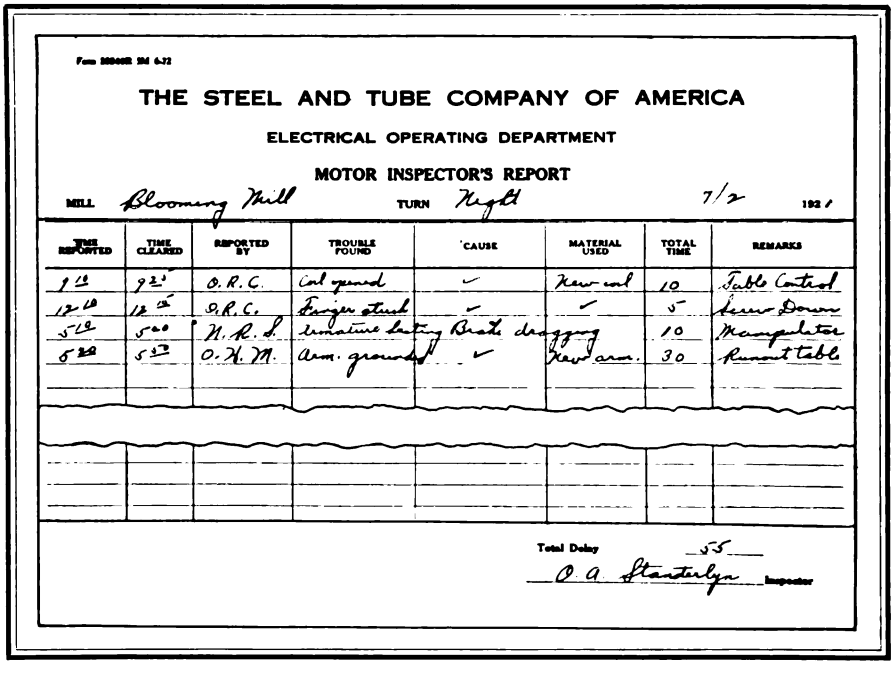
The construction section does the actual installation or changing of the work that the engineering section lays out. To do this it is necessary that certain orders or instructions should be issued so that the construction section will have the necessary authority and know how to proceed with the work. The information concerning the job is given in the form of blue prints or a letter of instructions. The authority for the job is given in the form of a department shop order, a copy of which is shown as Fig. 2. These shop orders are numbered when printed so as to prevent incorrect or duplicate numbers being put on them. In this way there are never two shop orders with the same number in the plant. In the upper left-hand corner is a space for the name of the department doing the work. On the right hand side is a space for the name of the department or the account to be charged for it. Beneath this on the line marked Apparatus is written the name of the job or the apparatus.

There is also room for a brief description of the work to be done, together with the numbers of the blue prints giving the details of the job. Near the bottom of the shop order are spaces to put the date when it is desired that the work shall be completed, for the signature of the originator of the order, with date.

Five copies of this order are made out. The first one goes to the department or section doing the work. This provides it with the authority to do the work and gives it either an account number to charge the labor and material to or else it is charged against the shop order number to the department having the work done. The second copy goes to the payroll department, so that it may make the proper labor distribution. The third copy goes to the storeroom, so that it may make the proper stores distribution of the material charged against the order. The fourth copy goes to the superintendent of the department being charged, so that he may know what he is paying for. The fifth copy is for the file of the originator of the shop order. Each copy is printed on a different colored sheet for convenience in handling and locating the orders.

These shop orders are originated by the engineering section for all new work or major changes of old work. They are issued by the maintenance section for all repairs or minor changes. Usually the head of the section signs the order originating in his section. These shop orders are executed by the various shops

Fig. 3.—Motor inspectors are required to account for their work on this form.



THE STEEL AND TUBE COMPANY OF AMERICA

ELECTRICAL OPERATING DEPARTMENT

MOTOR INSPECTOR'S REPORT

MILL Blooming Mill TURN Night 7/2 1921

TIME REPORTED	TIME CLEARED	REPORTED BY	TROUBLE FOUND	CAUSE	MATERIAL USED	TOTAL TIME	REMARKS
1 10	9 25	O.R.C.	Coil grounded	✓	New coil	10	Table Control
12 10	12 15	O.R.C.	Finger stuck	✓	✓	5	Screw Down
5 10	5 20	M.R.L.	Intermittent latch	Brush dragging		10	Manipulator
5 22	5 52	O.K.M.	Arm grounded	✓	New arm	30	Runout table

Total Delay 55

O A Standerlyn Inspector

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mentioned above and they constitute the authority for any work done.

The file of these orders at each of the places to which they are sent makes possible an account of the work done and that which is yet to be done. It also makes available a record of the activities of both the repair and construction sections.

It is more difficult to account for the work of the maintenance section. It is the duty of this section to watch the machines and keep them running. A record is kept of the power house and substation operators by means of the daily log sheets which were shown in the article in the April, 1923, issue. These sheets make a complete record of the work of their machines and this in itself accounts for the work of the men.

The motor inspectors are required to account for their work on the motor inspector's report form, a copy of which is shown as Fig. 3. This form is made out daily by each motor inspector. Spaces are provided for the name of the mill worked in, the turn and date, the time trouble was reported, the time it was cleared, by whom trouble was reported, the trouble found, its cause, material used, total time of delay and remarks. This sheet goes to the chief motor inspector, to the electrical superintendent, and then to the file. As can be seen, the file of these reports gives a very good accounting of the activities of the motor inspectors.

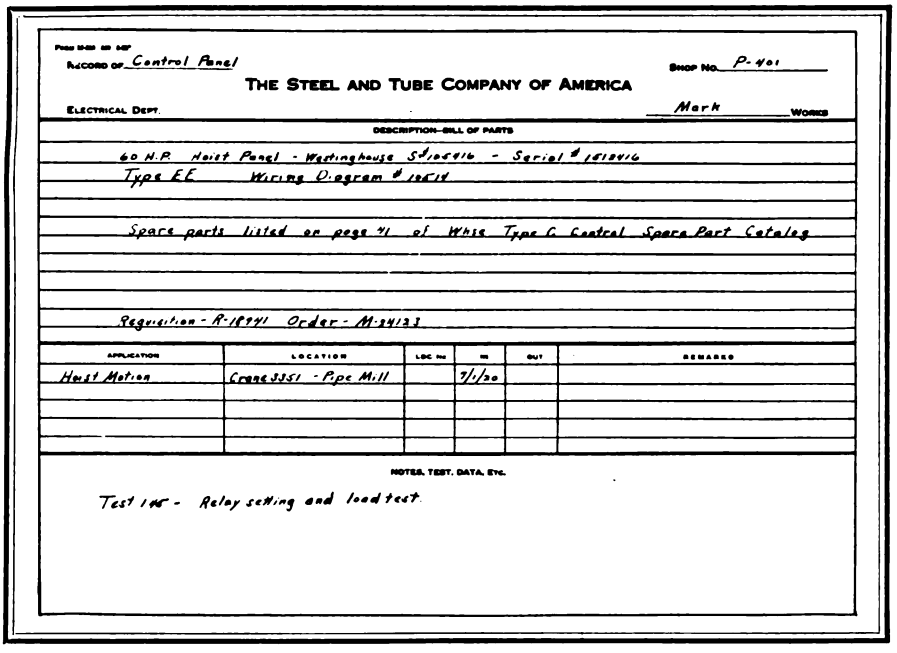
In the foregoing the author has attempted to show how the work of the men is accounted for and in what manner their work is checked. It is probably unnecessary to say that an accurate record is kept by the timekeeper of the time they work and in general the class of work they are doing. It is on the basis of the timekeeper's record that they are paid.

A record of the electrical equipment is of value for the following reasons:

1. It provides an inventory of the equipment in the plant.
2. It tells where the equipment is in use and gives the location.
3. It gives the data necessary for ordering spare parts.
4. It provides complete information, or indexes such information, so that it is unnecessary to go to the equipment in order to find it.
5. It indexes all the drawing numbers applying directly to the equipment and thus simplifies the work of finding a wiring diagram of a particular job.
6. It furnishes the purchase data; that is, order number, date of receiving it, etc.
7. It can be made to give the cost of operating the equipment.

There are two ways of keeping an equipment record. One way is to number each application or location and record the equipment at that location under this number. The other way is to number each piece of apparatus and to group the cards for each piece of apparatus in the file according to its location; that is, all of the apparatus for an individual application or drive is filed together in one folder.

The first method has the advantage that it is possible to keep on one card the cost of maintaining a



Record of Control Panel — Shop No. P-401

THE STEEL AND TUBE COMPANY OF AMERICA

Electrical Dept. — Mark — Works

Description—Bill of Parts

60 H.P. Hoist Panel - Westinghouse Std 106416 - Serial # 1518416
Type EE Wiring Diagram # 106114

Spare parts listed on page 41 of White Type C Control Spare Part Catalog

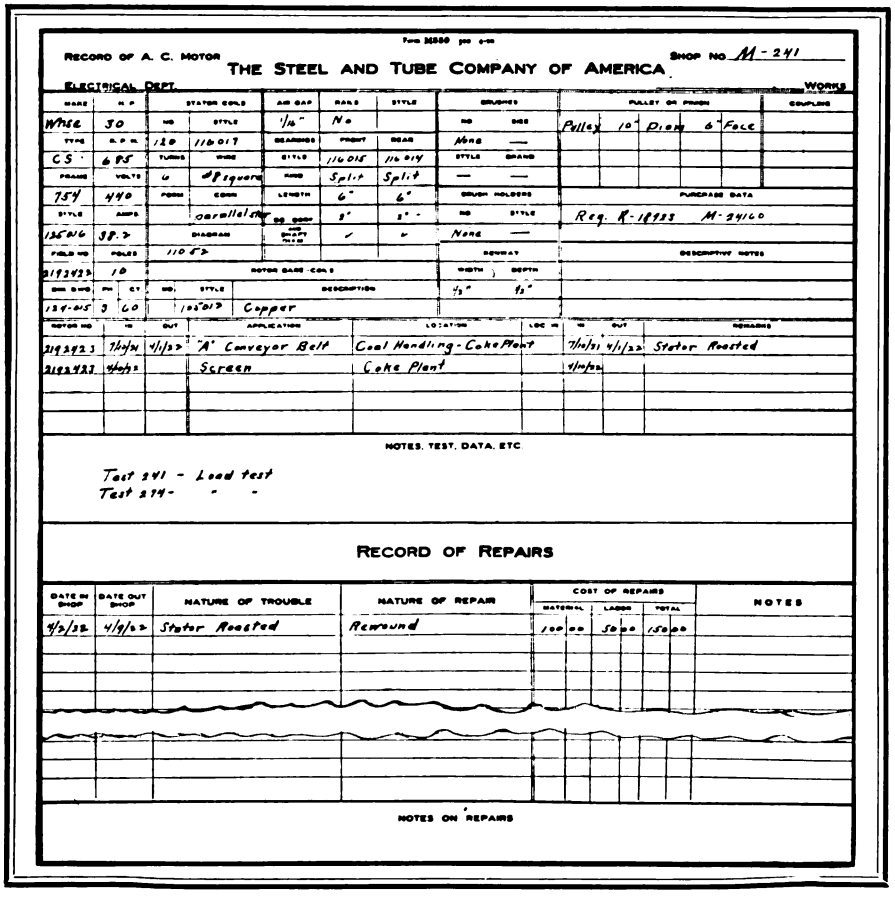
Requisition - R-18941 Order - M-24123

Application	Location	Loc. No.	In	Out	Remarks
Hoist Motion	Crane 3351 - Pipe Mill		7/1/22		

Notes, Test, Data, Etc.

Test 145 - Relay setting and load test

Fig. 5.—General form of card used for apparatus other than motors. The back is the same as Fig. 4.



Record of A. C. Motor — Shop No. M-241

THE STEEL AND TUBE COMPANY OF AMERICA

Electrical Dept. — Works

Make	H.P.	Stator Coils No.	Stator Coils Style	Air Gap	Rails	Style	Brushes No.	Brushes Size	Pulley or Pinion	Coupling
White	30			1/16"	No				Pulley 10" Diam 6 Face	
Type	R.P.M.	720	116017	Bearings	Front	Rear	Make	—		
C.S.	695	Turns	Wire	Style	116015	116014	Style	Grade		
Frame	Volts	6	4 sq.	Ring	Split	Split	—	—		
754	440	Poles	Coils	Length	6"	6"	Brush Holders		Purchase Data	
Style	Amps.		parallel	Dia. Comm.	5"	5"	No.	Style	Req. R-18993 M-24160	
136016	38.2	Diagram		Air Duct Yoke	✓	✓	None	—		
Field No.	Poles	1105					Rotary		Descriptive Notes	
2192923	10	Rotor Bars - Coils					Width	Depth		
Size Band	No.	Cu.	No.	Style	Description		1/2"	1/2"		
134-015	3	60		105017	Copper					

Motor No.	In	Out	Application	Location	Loc. No.	In	Out	Remarks
2192923	7/6/21	4/1/22	"A" Conveyor Belt	Coal Handling - Coke Plant		7/6/21	4/1/22	Stator Roasted
2192923	4/6/22		Screen	Coke Plant		4/6/22		

Notes, Test, Data, Etc.

Test 241 - Load test
Test 274 - " "

Record of Repairs

Date In Shop	Date Out Shop	Nature of Trouble	Nature of Repair	Cost of Repairs Material	Labor	Total	Notes
4/2/22	4/8/22	Stator Roasted	Rewound	100 00	50 00	150 00	

Notes on Repairs

Fig. 4.—Card forms like this one are made out for each piece of apparatus that bears a shop number. This form shows the front and back of an alternating current motor record.

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certain kind of motor on a definite drive. This cost is very interesting because it gives the true cost of operating a particular class of motors on a fixed class of work.

The second method is advantageous in that it provides a more accurate record of each piece of apparatus and gives the history of each particular piece from the time it enters the plant until it is scrapped. In this case the cost of operating a motor is kept on the same card, but since the motor may be transferred from one job to another the cost obtained is that of running at several different locations and probably on dissimilar work.

At the Mark Plant it was thought that the advantage of accurate and complete information regarding the apparatus was of more advantage than the actual cost of a certain kind of apparatus doing a definite cycle of work. This is correct because the equipment record is intended primarily as a record of the information regarding the equipment, rather than the cost of operating it.

Each major piece of apparatus is given a *Shop Number.* These shop numbers have different letters prefixed to them indicating what kind of apparatus the number is attached to. The pieces of equipment are numbered and a letter is prefixed to the number as follows:

PREFIX	APPARATUS
A	Large apparatus such as generators, main-drive motors, etc.
B	Electric brakes.
M	Motors.
P	Control panels.
R	Resistors.
S	Auto-starters, drum controllers, master switches.
T	Transformers.
X	Limit switches.

Brass tags with shop numbers etched below the surface and the etching painted black are attached to the various pieces of apparatus. These tags are much more durable than the usual run of nameplates. The tags are fastened to the iron work with machine screws so that they cannot be easily knocked off.

The reasons for using a shop number are as follows:

1. Some apparatus does not have a serial number to identify it from other similar pieces, and from those pieces that do have serial numbers.
2. Some machines have numbers with seven or eight digits stamped in small letters on the nameplate; these are hard to read and very liable to be read wrongly after they become corroded.
3. The shop number tag never has more than four digits. The digits are about ⅜-in. high compared to the ⅛-in. numbers on the manufacturer's nameplate.

Two records of these shop numbers are kept. In one book the shop numbers are listed in numerical order, all the *M* numbers together, all the *T* numbers together, and so on. It is from this book that the numbers are assigned. The file is made up in the following form:

Fig. 6.—Form used to indicate changes that are made and transfers of equipment from one department to another.

THE STEEL AND TUBE COMPANY OF AMERICA
MARK PLANT
TRANSFER REPORT

ELECTRICAL DEPARTMENT DATE OF EXCHANGE 4/1 1922

Apparatus Changed		
Kind of Apparatus	Motor	
	Apparatus Removed	Apparatus Installed
Type	CS (Whse)	CS
Frame	754	784
Size or Ratng	30 H.P.	30 H.P
Style No.	756114	756114
S. O. No.	✓	✓
Serial No.	2192422	2192570
Motor Field No.	✓	✓
Motor Armature No.	2192423	2192571
Shop No.	M-241	M-354

Cause of Exchange						
Motors	Rewind	Grounded	Shorted	Open	Bands or Wedges	Rough or Grooved
Armature						
Rotor						
Shunt Field						
Series Field						
Interpole Field						
Stator	✓		✓			
Commutator						
Slip Rings						
Bearing Trouble						

Assignment Data

New Apparatus Installed In

Mill Coke Plant

Drive "A" conveyor belt

New Apparatus Obtained From

Mill Spare stock at electric shop

Drive

Old Apparatus Sent To

Electric Shop

J. B Ericson Field Foreman

Approved

Cause Not Covered Above To Be Noted Below

Repairs Necessary in Electric Shop

Rewind stator

Electric Shop Order No. 24126

A. R. Dibbens Elec. Shop Foreman

Transfer Report No. 105

MOTORS

No.	SER. No.	MFG.	TYPE	H.P.
M-1	2367457	Whse.	30 M C	15
M-2	2517831	Whse.	50 M C	37½
M-3	2537954	Whse.	20 M C	7½

This file also furnishes a quick method of finding the serial number of a motor if the shop number is known, and the nameplate is gone.

In the other record all the pieces of apparatus of the same class and size are listed together; that is, all the 5-hp. squirrel cage motors are listed together, all the 10-hp. squirrel cage motors are listed together, all the 20 M C mill-type motors are listed together, all the 10-hp. adjustable speed motors are listed together, and so on. The form of the file is shown on page 431.

From this file the total number of similar motors of a given horsepower can be readily obtained. Since the order number for each motor is given, the cost price can be readily obtained together with the complete purchase data.

This list takes very little time to maintain, for entries are made in it only when a new piece of apparatus is received. The list forms a very convenient means of tabulating the various data that are required when taking inventory, appraisal, estimating tax assessments, or merely when the boss wants to know how many motors of a given size and type are in use so that he may determine how

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Form of File to List Apparatus of Same Size and Class

20 M C MILL TYPE MOTORS

Shop No.	Ser. No.	Mfg.	Type	Purchase Order No.	Original Assignment
M 241	261,270	Whse.	20 M C A	M 24,601	Trolley Crane 3,215
M 259	261,290	Whse.	20 M C B	M 24,609	Trolley Crane 3,240
M 274	261,300	Whse.	20 M C B	M 25,000	O. H. Door
M 291	261,405	Whse.	20 M C A	M 25,010	Spare

many spare motors he should carry for each class.

A card is made out for each piece of apparatus to which a shop number is assigned. Three forms of cards are used, one for a. c. motors, one for d. c. motors and one more general card for all other apparatus. Fig. 4 shows the a.c. motor card. On it are spaces for almost all of the information one is likely to need in the ordinary run of plant work. This card either gives or indexes all the information at hand on the particular motor in question. In the middle of the card is space for recording the application and location to which motor is assigned and for each change thereafter. At the bottom is a space for test data or for referring to test reports giving the details of tests taken from time to time. On the back of the card is space for recording the repair costs.

The d. c. motor card is the same as the a. c. motor card except that the spaces are marked in a manner suitable for a d. c. motor.

All of the other apparatus is recorded on the general card. This applies to control panels, master switches, drum controllers, resistors, limit switches, transformers, very large apparatus, auto-starters, and so on. A separate card is provided for each piece; that is, for each set of resistance, for each control panel, and so forth. The following information is usually tabulated on this card:

Shop Number.
Serial Number.
Name of Apparatus.
Size or Horsepower.
Manufacturer.
Type or Style.
Wiring Diagram Number.
Purchase Order Number.
Spare Parts Cat. Number and Page.
Any other information at hand.

This card also provides space for giving the location of the apparatus and the dates of changing its location. On the reverse side of the card is space for entering the repair costs.

These cards are filed in folders and each folder is for one application or drive. The folder for the hoist motion of a crane would contain a d. c. motor card with a shop number M———, a card for the control panel, with shop number P———, a card for the master switch with shop number S———, a card for the resistors with shop number R———, a card for the limit switch with shop number X——— and a card for the electric brake with shop number B———.

The bridge motion of the same crane would be filed in the adjacent folder and would contain a motor card, a master switch card, a panel card and a resistor card.

One drawer of the file is assigned to each mill and the folders are located in the file in the order of the applications or drives when going from the beginning of the mill to the finishing end. The name of the drive is typewritten on the projecting top of the folder so that it is an easy matter to locate any application almost instantly.

It often becomes necessary to move or exchange a motor on a drive because the motor may be too small or too large, or it may fail from overload or prove defective. If these changes are not followed up in the equipment record file it soon becomes obsolete and of no value. The transfer report, Fig. 6, was devised to take care of this in a routine manner. This form is made out by the chief motor inspector and is made for each piece of apparatus with a shop number that is moved, installed or exchanged. As will be seen from the form there is a space for the kind of apparatus and the date of exchange. Then follow two columns for the data on the apparatus removed and the apparatus installed. The data recorded are type, frame, size or rating, manufacturer's style number, the serial number, the armature serial number and the shop number. Below is space for giving the assignment data—when the new apparatus was installed, where it was obtained from, and what disposition was made of the old apparatus. On the right-hand side of the sheet is a place for checking the cause of the failure.

This sheet is sent to the shop foreman, who checks the cause of failure and notes, in the space provided, the repairs necessary in the shop. It then goes to the electrical superintendent, who has the transfer recorded in the equipment file.

It is from these sheets that the motor failure report is made. This is a tabulation of the motor failures classified as to whether they are armature, rotor, shunt field, series field, interpole field, stator, commutator, slip ring or bearing trouble. In one report the failures are classified according to kind and size of motor; in another they are classified according to the application. The idea is to determine which motors or applications are having an undue number of failures and what steps should be taken to reduce the trouble. This phase of the work was discussed in detail in the August, 1922, issue of INDUSTRIAL ENGINEER with a tabulation of troubles and their causes taken from these record forms.

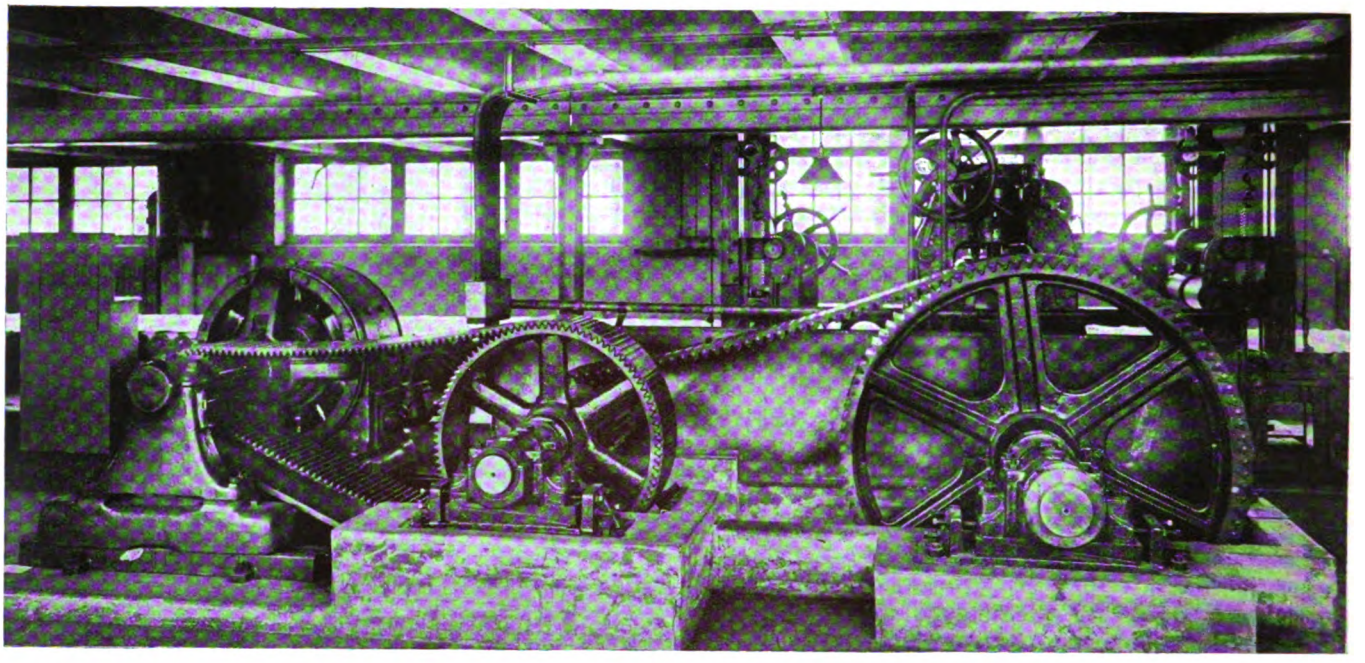
Take a Look at Your Roof Sign

While we are on the subject of plant maintenance, let me remark that a good many industrial signs are not creating the favorable impression that their owners fondly imagine they are. A sloppy sign does not help to sell an organization. If you have a painted sign that is showing the effect of wind and weather, better ask the sign company to get out the old paint brush and touch it up a bit. If it's an electric sign, look at it through the eyes of an outsider and see what kind of an impression it gives. Have all of the lamps washed and the empty sockets refilled, and look it over again.

Think this over—If the sign was worth putting up in the first place, it is worth maintaining in an attractive condition.

Practical Pete

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This 350-hp. double-reduction drive connected to a lead rolling mill drive is designed to reverse in operation under load.

Practical Details Showing How

Chain Drives Have Reduced Production Losses

By Transmitting Power Without Any Decrease in Speed Which Resulted in Increased Production at Machines

By FRANK E. GOODING
Associate Editor, Industrial Engineer

ELIMINATION of belt slippage and gear trains, as stated in previous articles in this series, is one of the principal advantages in chain drive installations. The big disadvantage of slippage is that it is almost unnoticeable and unless measurements are taken it is frequently not even considered as an element responsible for production losses. What this loss amounts to and the advantages resulting from the prevention of slippage are well illustrated by the following interesting experience of H. R. Wright, industrial engineer at the Automatic Electric Company, Chicago, Ill. His experience is similar to that in many other plants and emphasizes the close relationship between maintenance and production.

At this plant, the men are paid under a plan whereby they are guaranteed a certain hourly rate and in addition each job has a piece rate under which, with consistent effort, a mechanic can earn a bonus of about 20 per cent extra. When conditions are such that on straight production the men cannot earn this extra bonus they immediately complain. About three years ago, an avalanche of complaints seemed to come from the operators of a group of twenty-eight punch presses driven by a 15-hp. motor through a lineshaft. Occasional individual complaints on inability to maintain a bonus may be expected, due to defects in tools or raw materials or to errors in the time study and rate setting. These can be easily checked and corrected. It is an entirely different matter, however, when virtually one-half of the department enters a complaint.

In such cases, the mistake is often made of thinking that the complaints are due to a concerted action of the men, through an attempt to force changes in the rate. Here, however, it was thought something else was wrong. The motor speed was checked and found to be up to its rating of 790 r.p.m., but this did not satisfy the men.

Finally a check was made on the lineshaft speed. A 12⅝-in. pulley on the motor driving a 52-in. lineshaft pulley should give 191.8 r. p. m. on the lineshaft. The test showed a speed of only about 180 r. p. m. or a loss of 6 per cent which was attributed to creep and slippage. This loss was equivalent to having about 1⅓ presses operating but not accomplishing anything, based on the

IN THIS ARTICLE, which is the third of a series on chain drives, beginning in the July issue, practical details are given for a specific installation showing the results obtained in terms of production. Information is also included supplementing the second article on "Operating Conditions Affecting Chain Service" which appeared in the August issue.

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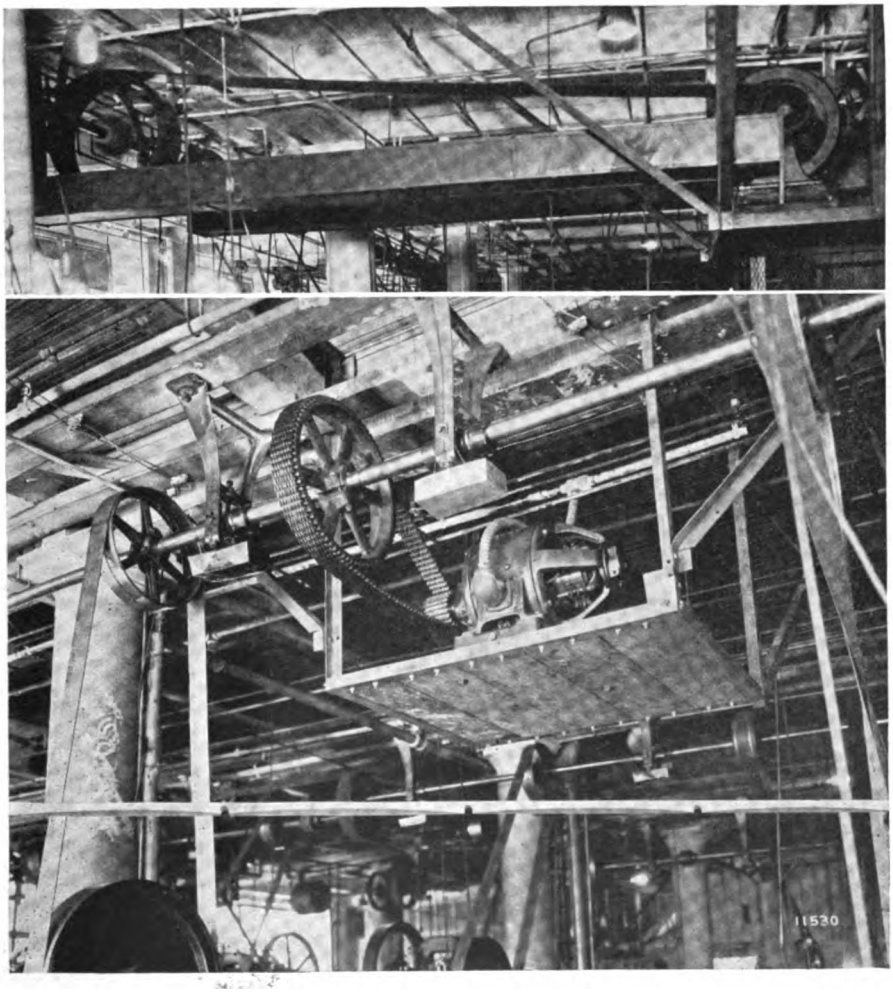
estimate of twenty-three of the twenty-eight presses in the group operating continuously. About five presses are idle for changing dies, making repairs, and other similar work.

Tightening the driving belt did not eliminate the complaints. Finally it was decided to try out a silent chain drive from the motor to the lineshaft instead of buying a new belt which would have cost about $49 with an approximate life of four years. A silent chain, sprocket and pinion cost $109.53 and has an estimated life of ten years. The size of the sprocket and pinion was determined by the engineering department of the Link-Belt Company, who made the installation. In this case, a sprocket with 78 teeth and a pinion with 19 teeth on a 15-hp. motor was driven by silent chain 3½ in. wide and 1 in. pitch. The driving motor was placed on a special platform close to the shaft instead of about fourteen feet away as was the practice with the belt drive and required only 9 ft. 6 in. of chain instead of 35 ft. of belt.

After the installation was in, a check showed a lineshaft speed of 192 r. p. m. and that group of men has made no concerted complaint since. However, another group of punch press operators in the same department immediately asked for a chain drive on their lineshaft and kept on until they got it.

The platform carrying the motors has been standardized as to form and specifications of materials, but its dimensions vary according to the size of the motors, which, on the various installations already made have varied from 15 to 25 hp. This platform, which is easily seen in the lower of the pair of illustrations below, is substantial enough for any of them. It is easily constructed and erected and provides ample space for working around the motor without erecting special staging. In a word, it is considered to be much more advantageous than to suspend the motor upside down from the ceiling as it allows access for any necessary repairs or inspections.

Now, at the plant of the Automatic Electric Company six lineshaft silent chain drive installations have been made. Three more are ordered and in addition, as fast as a belt begins to deteriorate rapidly, a chain drive is ordered instead of replacing the belt. Similar conditions may be found in practically any plant as the men responsible for production in but few plants take the trouble frequently to check up the lineshaft speed to see that they are getting what they think they are. However, the estimated speed of the lineshaft is usually used in determining standard time for rate setting. In some instances production increases of 5 to 15 per cent have resulted simply through making changes which have resulted in obtaining the proper lineshaft speed.



A belt drive and the silent chain drive which replaced it.

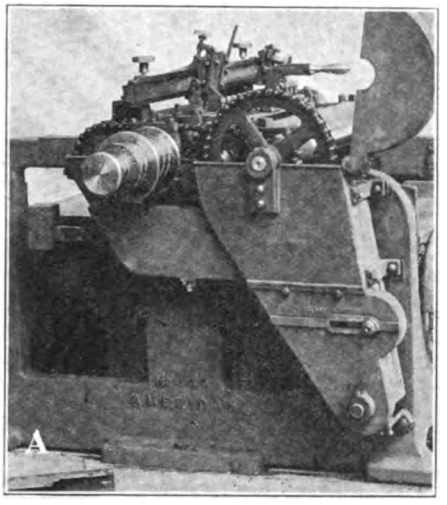
One of the six silent chain drive installations at the Automatic Electric Company's plant which drives a group of light drill presses and other machines. The illustration at the top shows the motor drive and long belt and guard extending across the aisle before the change was made. A sheet metal case was put over the chain after the photograph was taken. The lower photograph shows the standard platform used for mounting motors.

The Use of Back-Type Chain in Automobile Drives

The previous articles have, in a general way, covered silent chain drives in so far as the application to industrial work is concerned. Another use consists of the application of silent chain drives to the front end of automobile motors to actuate cam-and other shafts. This use has become practically a standard on the better type of engine to take the place of the train of small gears otherwise employed. The front of the engine requires a medium that would be quiet in operation, efficient, economical, durable and be readily replaced. The chain manufacturers have had to solve the problems of material, stretching, and absolute interchangeability of parts for successful operation. Just one element alone may be emphasized; that is, the substitution of the chain drive has completely eliminated the troublesome expense and time-consuming "matching" and "lapping-in" required by gears.

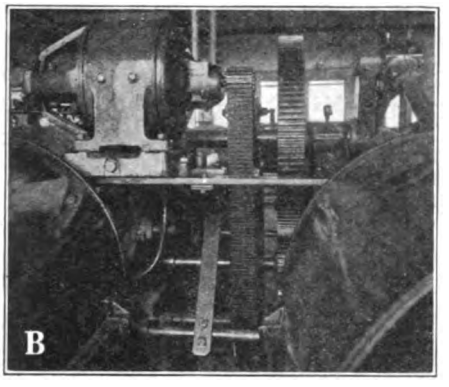
There are, generally speaking, two types of layouts, the triangular form with manual adjustments and the automatic tightener and vibration damping type as shown in the illustrations. The latter form is unique in that it employs what is known as "Back Type" chain, designed to drive with both front and back of chain, thus permitting the designer and builder to locate the shafts and

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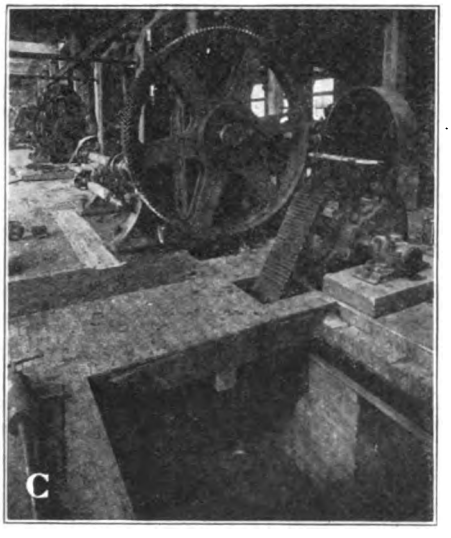
Some Applications of Silent Chain Drives *in Industrial Works*

A—A common application of roller chain drives is to connect up working parts of machines which must operate in exact speed relations as in woodworking and some other machinery.



B—This machine for working candy was rebuilt from countershaft drive at Bunte Brothers, Chicago, Ill., when the plant was moved into a new building.

C—This group of calenders in a rubber mill is connected to a 150-hp. motor by a silent chain of 1½-in. pitch, 15 in. wide, on 96-in. centers.



D—Here a 50-hp. motor is connected up to a rope drive in a dusty elevator by a silent chain drive of 1 in. pitch operating over 19 teeth in the pinion and 71 teeth in the sprocket.

E—The motor is connected by silent chains to two beater drives in a paper mill. This is a type of drive well suited to silent chains.

F—These lineshaft and belt drives in a textile mill were taken out and motor and silent chains installed as shown at the right. Belts stir up dust and lint, which settle on the work. Also oil which drips from overhead bearings damages textiles. An increase in output from 3 to 10 per cent usually results from the more positive drive.

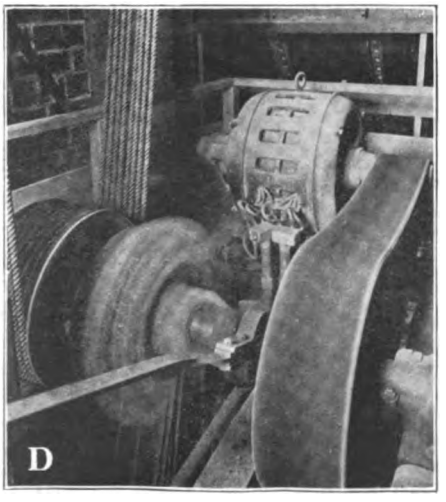
G—The row of countershafts overhead has not been taken down. The chains are enclosed in tight steel cases. The motors are mounted on special framework so designed as to be easily attached to the frames and carry the driving mechanism.

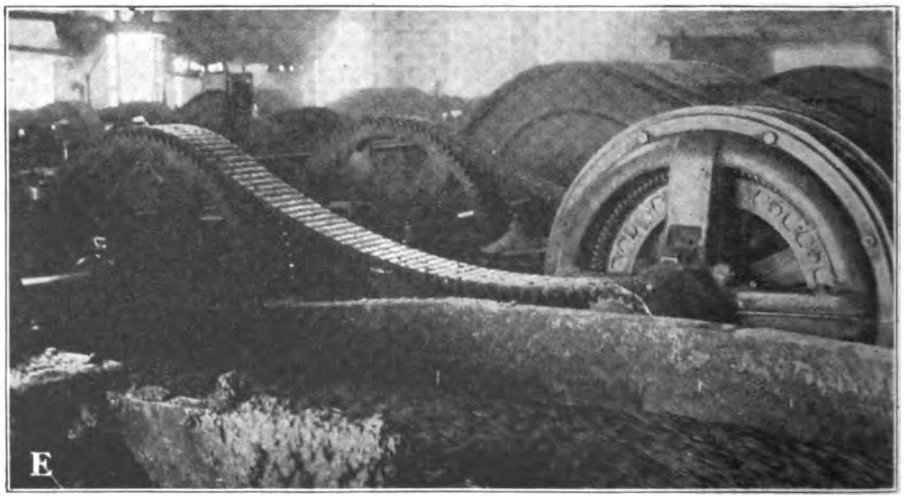
H—Ordinarily a chain drives from one side only. For special cases, as in this automobile motor, a special "back type" chain is used.

I—Air compressors, due to their shock load, are one of the most severe types of duty for silent chains. Here a heavy flywheel and a spring socket protect the chain and motor as well as smooth out pulsations.

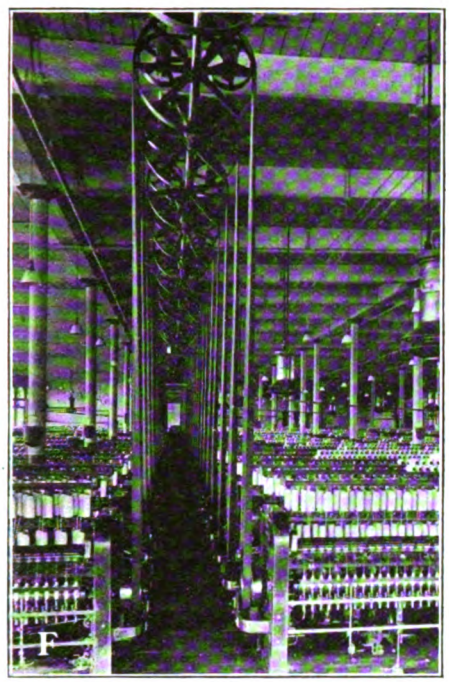
J—On printing presses the different rollers and feeds must be connected up so as to work in exact speed relation with each other. Silent chains instead of gear trains are now commonly used for this purpose, as shown here.

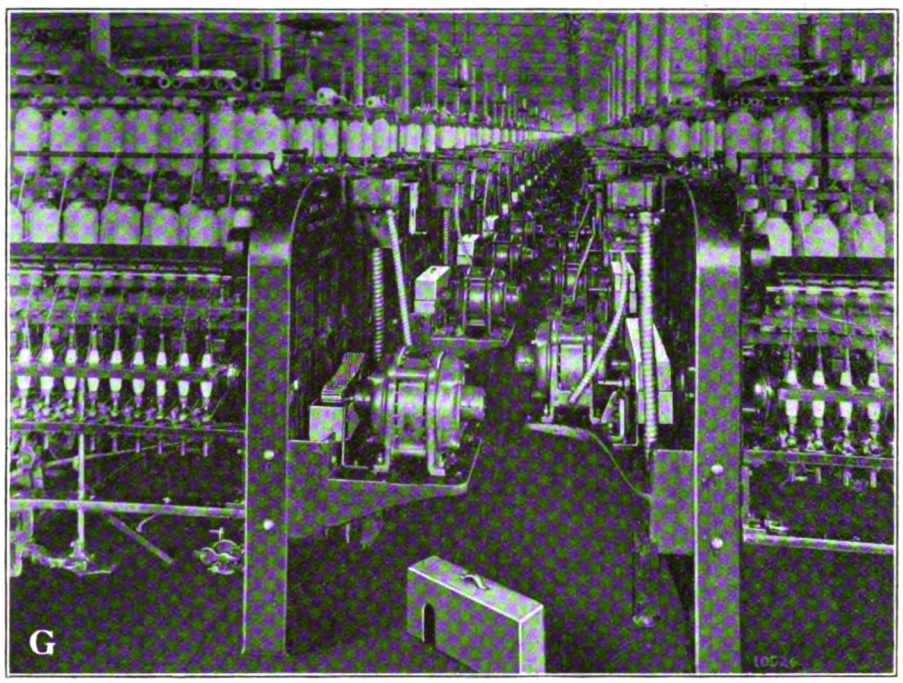
K—Punch-press work is another type of shock load which gives severe service on silent chains. Here the flywheel not only furnishes momentum but the teeth for the chain are cut in the face so that it acts as the sprocket. A positive drive increases production here. The motor is mounted on a bracket.

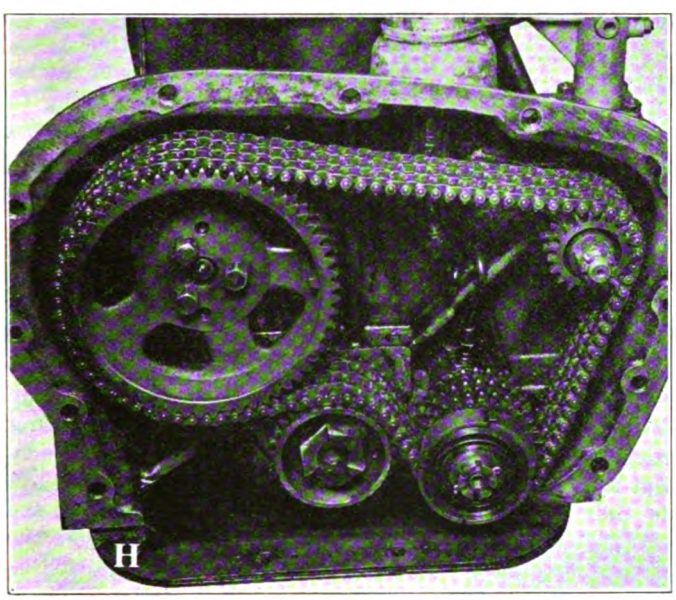


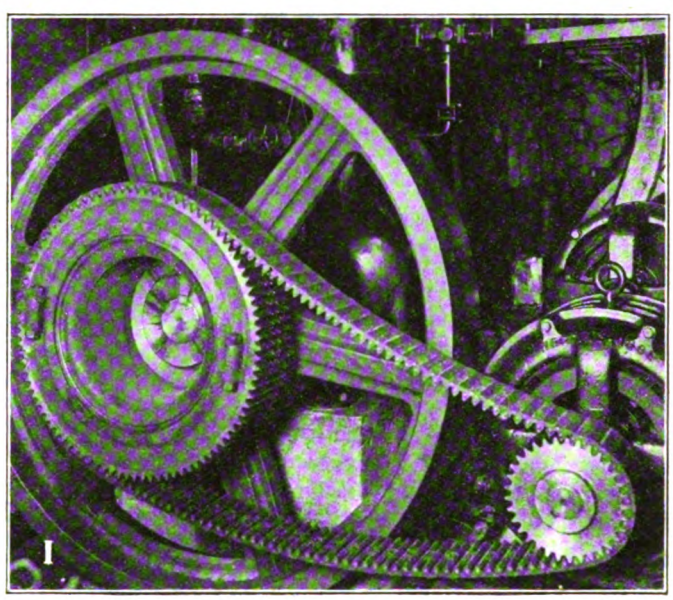


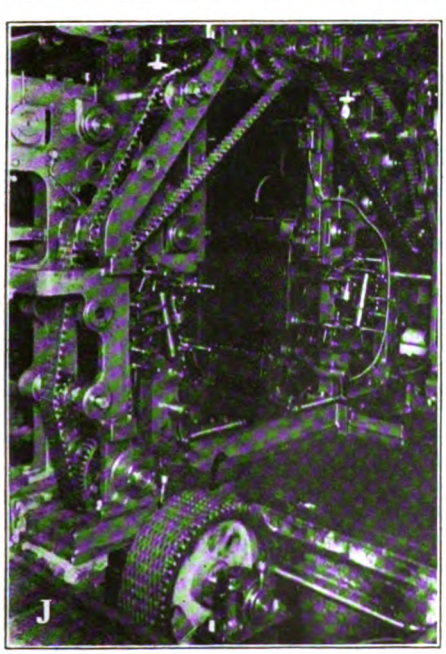
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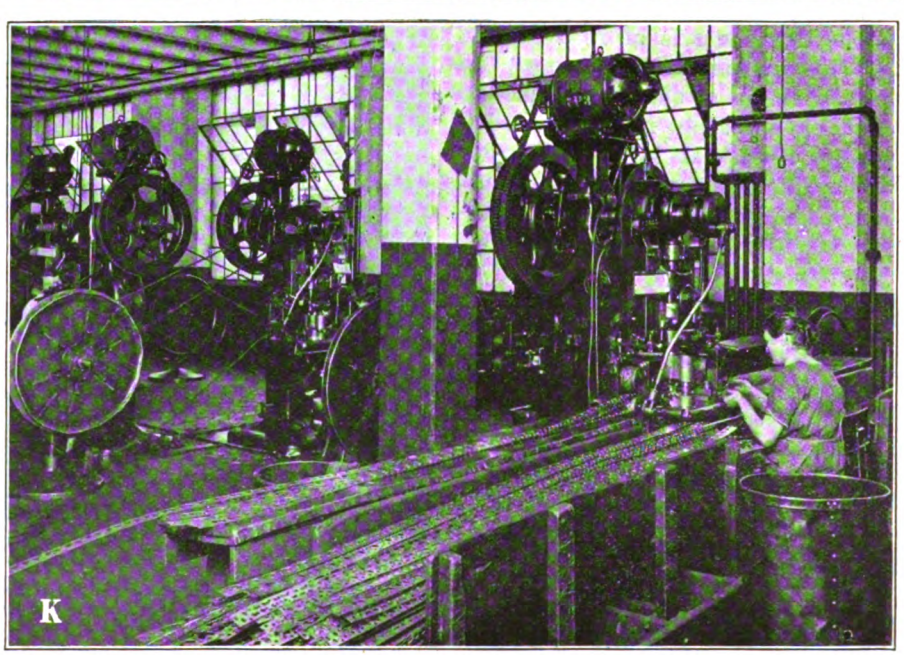

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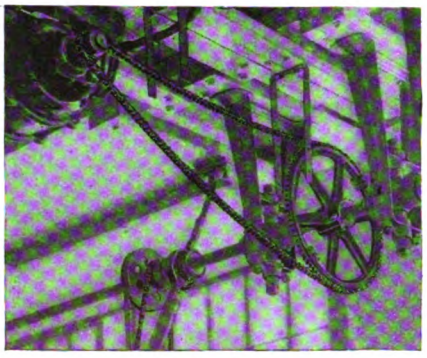
wheels wherever the highest efficiency and greatest economy in arrangement of parts may require.

An example of this type is shown in the front end automobile drive, illustrated on page 435. This chain has the appearance somewhat as though part of it were assembled upside down so that part of the chain meshes in teeth on one side and another part of the chain meshes in teeth on the back of the chain. The teeth which mesh with the front of the chain, however, are not in alignment with those that mesh with the back as may be seen by noticing the illustration already referred to.

Silent chains are made to drive from one side only and most types operate in either direction. When used on a reversing drive, due to the strain of the reversal, an extra horsepower rating is given to the chain and larger sprockets, preferably with about 25 per cent more teeth, are used. Many reversing drives of above 100 hp. are in satisfactory operation. If the links have arrows the arrows should point in the direction of the travel, or on reversing drives they should point in the direction of travel when operating under the heaviest load.

Information Necessary When Ordering Sprockets

Do not try to use a silent chain of one manufacture and sprocket of another even though they may be of the same pitch as the links of the various manufacturers are not the same. However, sprockets made to take roller chain of the "New American Standard" are standardized and interchangeable among other chains of the same pitch and with the same size of rollers made by the various manufacturers. Obviously chains of one pitch cannot be used on sprockets made for a different pitch. It is also advisable to buy the sprockets instead of cutting them unless the user has a cutter supplied by the manufacturer. Even then, a cutter can be used to cut only certain sizes of sprockets; for example, one cutter may cut teeth on sprockets of 15, 17, or 19 teeth and another cutter be required to cut sprockets of 21, 23, 25 or



Roller chain drive connecting motor to lineshaft and also from shaft to machine.

27 teeth, and so on. Also a complete set of cutters is required for each of the different pitches so that it is seldom profitable for an industrial plant to cut its own sprockets or pinions.

For ordering sprockets and pinions the following information should be given:

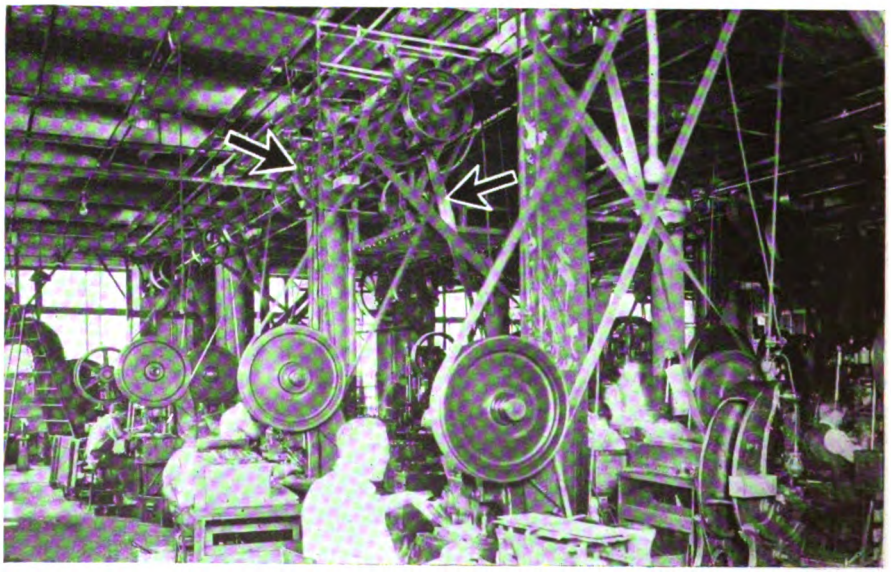
1—Style of sprocket.
2—Split or solid.
3—Model or type number of chain and pitch.
4—Width of chain.
5—Number of teeth in sprocket.
6—Bore.
7—Length of hub through bore.
8—Maximum hub diameter if there is a limitation on this by the design.
9—Size and location of keyways and set screws.
10—Send sketch if hub is offset or has other unusual features.

Practically the same information is necessary for ordering sprockets for roller chains except that the pitch diameter or outside diameter may be used.

It is frequently advisable to case-harden steel sprockets, particularly for roller chains. Sometimes when sprockets serve as idlers, such as in supporting an extra long chain or when necessary to carry the chain around an obstructing shaft, they are provided with bronze bushings and oil cups or other types of lubricators.

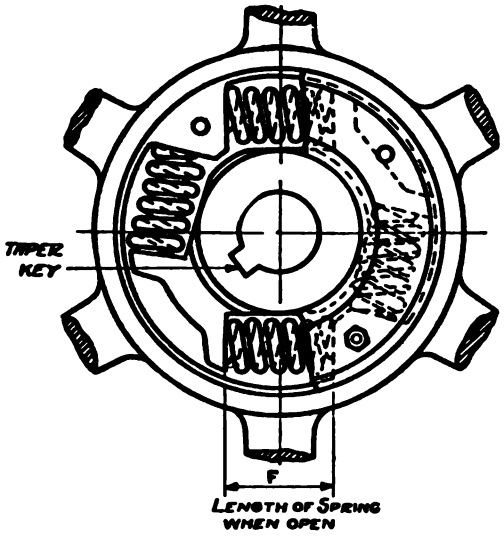
Some Methods of Absorbing Shock Loads

In addition to the natural elasticity of the chain, which will take care of any normal operating conditions such as starting except under full load, either spring center or shearing pin sprockets are used to take care of shock loads. Both of these are illustrated in the sketches reproduced on the opposite page. The spring center sprockets are used on punch presses, air compressors, gas engines and similar mechanisms where the shock load is in the form of momentary pulsations applied at infrequent periods. These special sprockets are used in addition to increasing the chain horsepower rating from 10 to 50 per cent according to the amount of the shock, as described previously. When determining the size of a spring center sprocket it is best to get one as large as the diameter of the wheel will permit. When the machinery driven by the chain is liable to become damaged by being stopped or stalled suddenly as on installations of deep-well pumps where gravel may get into the pump and stop it, shearing or breaking pin sprockets are recommended. These pins, as may be seen from the sketch, are the weakest points in the mechanism and will break under the load and protect the chain as well as the pump or other parts. These pins are easily replaced at small ex-



First chain drive installation at the Automatic Electric Company.
The belt from motor to lineshaft slipped enough to decrease the r.p.m. about 6 per cent and caused a loss of production. When the men complained, because they could not earn their bonus, a silent chain drive was installed.

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Spring-center sprockets are another form of protection against sudden overloads.

On punch presses, air compressors, gas engines or where the load consists of a series of intermittent, momentary shocks, a spring construction such as this or other similar devices absorbs part of the shock and so protects the chain and the driver. In such cases, it is always advisable to increase the capacity of the chain from 10 to 50 per cent if it is expected to give satisfactory service under such operating conditions. In such cases fly-wheels are also often used to maintain the momentum and in some cases both are used. Probably the most punishing load is found in the case of a single-cylinder gas engine driving an air compressor.

pense. When the pins break the sprocket will simply revolve on its hub.

Frequently shearing pin sprockets are provided with several pins so that the amount of overload which they will stand before shearing may be graduated. In such cases each pin will carry about twice the normal load rating before shearing. Ordinarily not more than two or three pins should be used as they will stand an overload of from four to six times normal rating, which is as heavy as may be safely applied.

Spring sprockets must be oiled or greased when installed and at frequent periods later while in operation. The common method is to remove plugs from spring sprockets and fill with oil or graphite paste. The bearing surface between the outer sprocket and the inner surface must also be oiled.

Another advantage of chain drives lies in the ease with which the speed ratios may be changed. To increase or decrease fixed speed ratios, it is only necessary to change one of the sprockets, and lengthen or shorten the chain as required. In exceptional cases, when a fixed ratio must be obtained it may be necessary to change both sprockets. Unless the center lines of the driving and driven shafts are too close this center distance need not be changed.

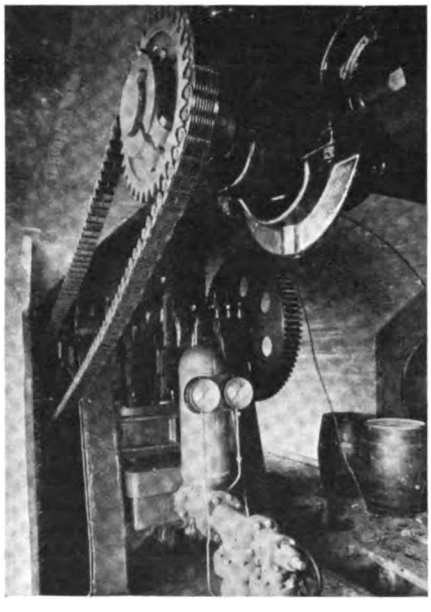
Some of the Common Abuses of Silent Chain Drives

In discussing the abuses of chain drives, one manufacturer has stated that most of them occur before the chain is put into operation, and listed seven items to look out for which may be termed errors in judgment. These are:

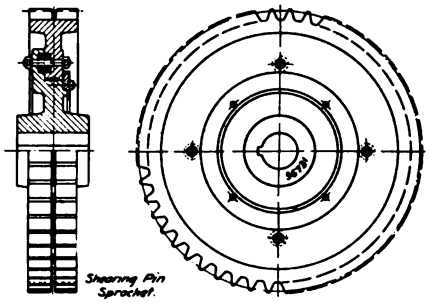
1—The chain may not be properly selected for the speed and the load.
2—The sprockets may not have the proper number of teeth.
3—The tooth forms may be wrong.
4—The sprockets may not be properly made.
5—The sprockets may not be in proper alignment.
6—Idler sprockets may be used when they should not be used.
7—Non-driving strand of chain may be too tight.

All of these points apply to the selection of either roller or silent chains. In addition, when selecting proper sprockets for roller chains, the following errors may occur: the bottom diameter may be too large, the teeth may be too thick, the bore may be eccentric, the hub or rim may be so large as to interfere with the side plates of the chains, chamfer in the sides of the teeth may be insufficient; the sprocket teeth may be casehardened without removing the burrs and sharp edges from the teeth.

In addition to these the abuses in



One of a battery of silent chain drives on pumps which maintain pressure on accumulators.



Use of shearing-pin sprockets is one method of protecting chain drives and the driving mechanism.

Where the driven machine is liable to be stopped suddenly ,as in cases when rock or gravel gets into deep-well pumps, the pin is sheared off and leaves the sprocket free to rotate on its hub. This protects the motor and the chain, as something must break in such cases.

operation consist mainly of insufficient lubrication, suddenly putting on full load at full speed, running a new chain over badly worn sprockets, and failure to take up the slack in chains in cases where "whipping" is severe. Whipping of the chains may also be due to intermittent loads and often can be prevented by the installation of a spring sprocket as previously described or by providing the proper size of balance wheel to absorb irregularities in momentum. Obviously rigid mountings are desirable although not as essential as with gearing. The type of mounting described in connection with the silent chain installation at the Automatic Electric Company is a convenient and easily constructed platform mounting for lineshaft drive.

Any mechanical equipment operates with better satisfaction if inspected periodically and any slight repairs made as necessary. Chain drives are no exception. In inspecting silent chains wear is evidenced by the chain climbing on the sprocket teeth. The position of the chain on large sprocket can be determined by holding a light at one side of the sprocket when running and looking through under the chain; it will be seen how far out on the teeth the chain is riding, and, if near the top, a new chain should be ordered or the old chain repinned with oversize pins to restore to original pitch. *A new sprocket will not remedy the trouble* as the fault is in the lengthened pitch of the chain and not in the sprocket. Other points on inspection and maintenance were discussed in previous articles.

To summarize the uniformity of silent chain drives for industrial purposes, *(Continued on page 470)*

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Some of the Ways That

Record Forms For Motor Installations

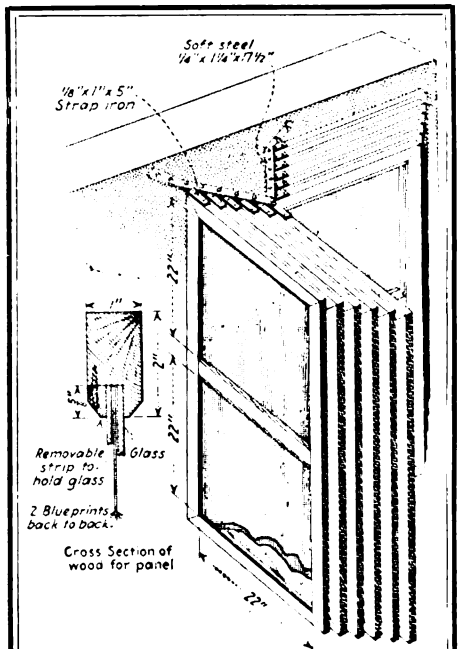
Can be Used to Prevent Mistakes and Save Time When Making Changes And Repairs or Ordering New Parts

By EDWIN S. WAGNER

Electrical Engineer, Hershey Chocolate Company, Hershey, Pa.

IN ANALYZING the installation requirements when replacing and shifting motors, ordering brushes, making repairs, and the like, in the plants of the Hershey Chocolate Company, a useful record system has been devised. This system includes a motor record, a bearing record and a brush record, besides a very convenient way of filing the larger records. All of these records are kept in the form of blue prints. The motor record illustrated below is kept on a sheet 22 in. square, which contains space for fifty motors. The record tells the purchase date and the date of receipt, the company's number, nameplate data of the motor, the time and place of installation and the machine driven and reference numbers of bearings and brushes.

The bearing reference numbers relating to the first motor in the motor record shown are 6219J[1] and 6218I[1], respectively, for the commutator and pulley ends. This figure is the number which was stamped on the bearing when it was received from the manufacturer. This is done to prevent mistakes in taking bearings out of stock, even though they may be accidentally placed in the wrong bins. The letter J[1] refers to the bin in which the bearing is kept. In our stock room the bins are run six rows high and twenty-six bins long. The bins in the top row are numbered A[1], B[1], C[1] etc., those in the second row A[2], B[2], *(Continued on page 468)*



A rack for mounting record sheets so that information for many motors can be quickly secured.

Each frame holds four sheets, each containing data on fifty motors. A sample motor record is shown below.

Brush chart which simplifies the ordering and replacing of brushes.

HERSHEY CHOCOLATE CO BRUSH DATA COMPILED FROM N.C.CO. BUL. NO. 34

LIST NUMBERS		LENGTH	WIDTH	THICK.	SPECIFICATIONS SHUNT	GRADE
41	8841	2"	1 1/8"	1/2"	No.6 x 5 1/2"	258
42	8842	2"	1 3/8"	3/8"	" " "	258
43	8843	1 1/4"	1 3/8"	3/8"	No. 9 x 5 1/2" 45° 45° 9/32"	258
44	8844	1 1/8"	1 1/8"	3/8"	" " " "	258
45	8845	2"	1 3/8"	1/2"	" " " "	255
46	8846	2"	1 1/8"	3/8"	No. 9 x 5 1/2" 45° 45°	407
47	8847	2"	1 1/4"	3/8"	No. 6-A x 5 1/2" 60° 9/32"	402

Motor record form and bearing record form which give details of all parts of a motor drive and eliminate guesswork when changes or repairs are needed.

The motor record is the top part of one of the forms mounted on the swinging frame shown above.

HERSHEY CHOCOLATE CO. MOTOR BEARING RECORD

	MANUFACTURERS SPECIFICATIONS										BEARINGS									
											STOCK NO.		SHAFTS DIAMS		LENGTH INCHES		OUTSIDE DIAM.		MFG. NUMBER	
OUR NO.	HP.	NAME	SERIAL NO.	WDG.	TYPE	FORM OR SIZE	VOLTS	AMP.	CURRENT	R.P.M.	COM.	PULLEY	COM.	PULLEY	COM.	PULLEY	COM.	PULLEY	COM.	PULLEY
20	5	C. W. Co.	136,015	Sh.	C.M.	1 L	220	19	D.C.	960	6219 J'	6218 I'	1 5/16"	1 5/16"	2 1/8"	3 1/4"	2 1/8"	2 1/8"		
62	3	G. E. Co.	372,135	Sh.		BB 101 C.Y.C.	220	11	D.C.	1650	6234 K'	6234 K'	1 1/4"	1 1/4"	3"	3"	1 1/16"	1 1/16"	343,246	343,246

HERSHEY CHOCOLATE CO. MOTOR RECORD

PURCHASE ORDER	DATE REC'D	OUR NO.	HP	MAKERS NAME	SERIAL NO.	WINDING	TYPE	FORM	SIZE	VOLTS	AMP.	CURRENT	R.P.M.	BEARINGS COM.	BEARINGS PULLEY	WHEN INSTALLED	LOCATION	DRIVE	BRUSHES
1014 of 1/19/12	3/1/12	20	5	Crocker Wheeler	136,015	Sh	C M		1 L	220	19	D.C.	960	6219 J'	6218 I'	13/6/12	24 bld'g. 4th floor	Vacuum fan	8846
499 of 2/4/16	4/3/16	45	60	Gen Elec Co.	129466	Comp.	C L	B		600	99	D.C	825	✓	✓	5/10/16	25 bld'g. 2nd floor	Day Mixer line shaft	8847
560 of 2/4/16		44	75	C W	250,953	3 phase 60 cycle			123	2200	14	A.C	665	8795 Q[2]	8795 Q[2]	25/10/16	25 bld'g. 3rd floor	South line shaft	

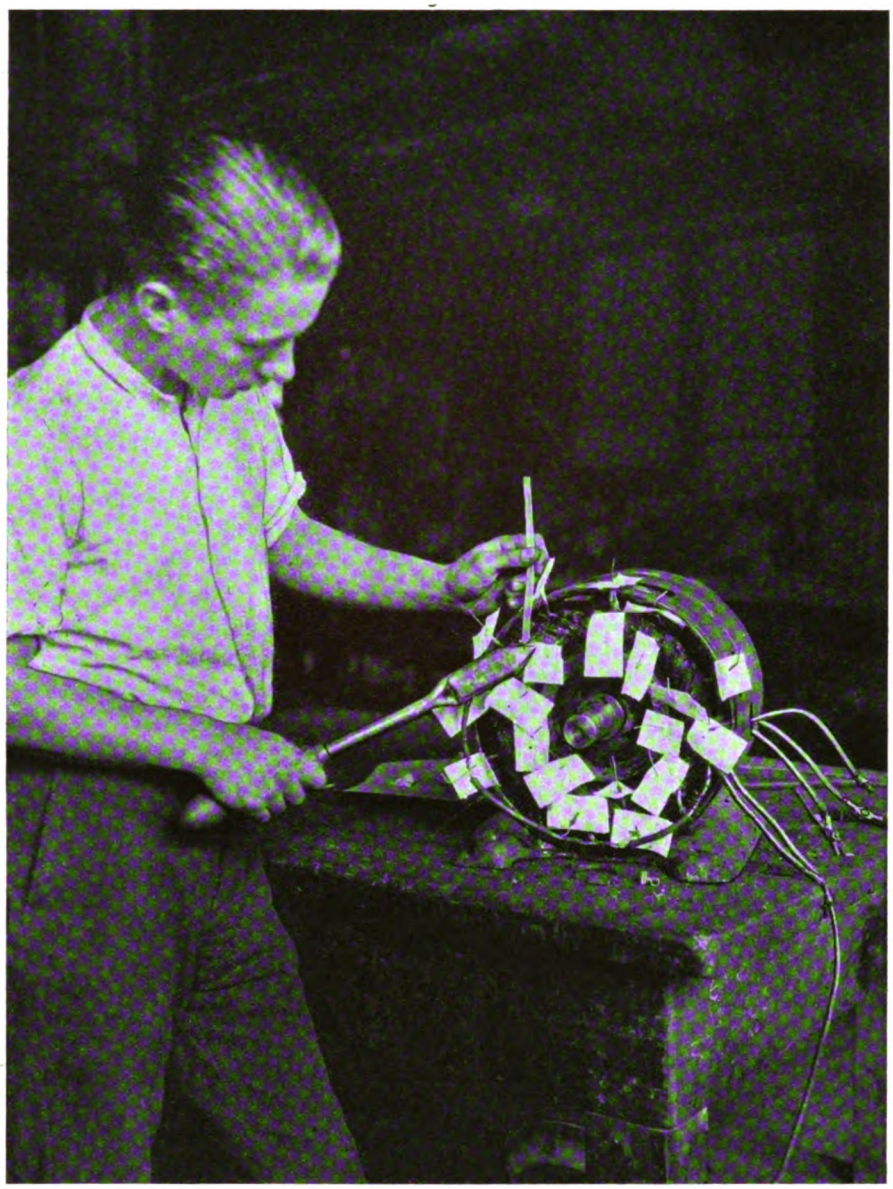
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WHEN A MAN knows just *why* a thing must be done in a certain way, he usually has no trouble in remembering *how* to do it. For this reason this article by Mr. Roe will be a great help to those who want to draw or check winding diagrams. He describes the developed type of diagram which shows every coil side and end connection as well as all stubs and jumpers. He then explains the simple single-line diagram and tells how a developed diagram may be changed to the single-line type. This is the first of a series of articles on laying out diagrams and procedure in connecting induction motors.

Steps in Laying Out and

Checking up Winding Diagrams

For All the Possible Operating Requirements of Induction Motors



After the winding is checked up even a boy can make the connections

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company

IT IS the purpose of this article to tell how to lay out and to check winding diagrams for lap-wound induction motors. The developed type of diagram, that is, the one which shows all coils as they are put into the slots with the connections, will be explained first. Then the simple single-line diagram showing only coil groups will be discussed. After this will come methods of checking windings to see if they will give correct operating conditions. The present article covers single-phase and two-phase diagrams. The three-phase diagrams will be taken up in a subsequent article. Finally, in later installments of this series will be given details of just how to make the connections of an actual motor winding. The series will cover lap and wave windings for one, two and three phases.

Before going into the details of single-phase diagrams, it will be helpful to study the general principles of single-phase machines. This is best done by drawings of a simple single-phase generator as shown in Fig. 1. The position of the windings on generators and motors follows in general the same principles.

Principle on Which a Single-Phase Machine Operates

The simplest kind of a generator is shown in Fig. 1. This shows two pole pieces, one north and one south, and a circle inside representing an iron core or armature. The two small circles, *a* and *b*, represent two conductors of one coil joined together to form a closed circuit so that current will flow. In this diagram the armature winding is assumed to be rotating, while the field poles are stationary. This is done in order to simplify the drawing. In actual practice, the armature winding is usually stationary, while the field poles revolve. In this diagram, the direction of rotation is assumed to be always clockwise.

It is a known fact that any conductor which is passed through a magnetic field in such a manner as to cut the lines of force of the field, will have a voltage induced in it, proportionate to the strength of the field and to the rate of the motion. If the conductor forms part of a closed circuit, a current will flow. If the conductor is forced through a magnetic field of uniform strength, at a uniform rate of speed, and the lines of force in this field are all in the same direction, a constant direct current would be induced in the con-

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ductor. However, when a conductor is rotated between two poles, as in Fig. 1, the voltage changes from time to time. For instance, when the conductors are in a position as shown in No. 1 (which is the position on the circle between the pole pieces), they are not cutting any lines of force and no voltage is generated. However, when the conductors are directly under the center of either pole (as in circles No. 7 and 19), they are cutting lines of force at the greatest rate, and the highest voltage is generated. Furthermore, when a conductor is under a north pole it generates voltage in one direction, and when it is under a south pole it generates voltage in another direction. Therefore, when we revolve the armature with the two conductors, the voltage is generated first in one direction, increasing to a maximum and passing back to zero, and then in the other direction, increasing to maximum and passing gradually back to zero. This is illustrated in detail in the small circles Nos. 2 to 25. In these small drawings, each successive drawing represents an advance of 15 electrical degrees for the conductors. The radius of the circle represents the maximum value of the induced voltage. Then the vertical line drawn from the horizontal or zero line to the conductor, *a*, represents the voltage being induced at any instant. This voltage is shown in all cases by the line *oa*.

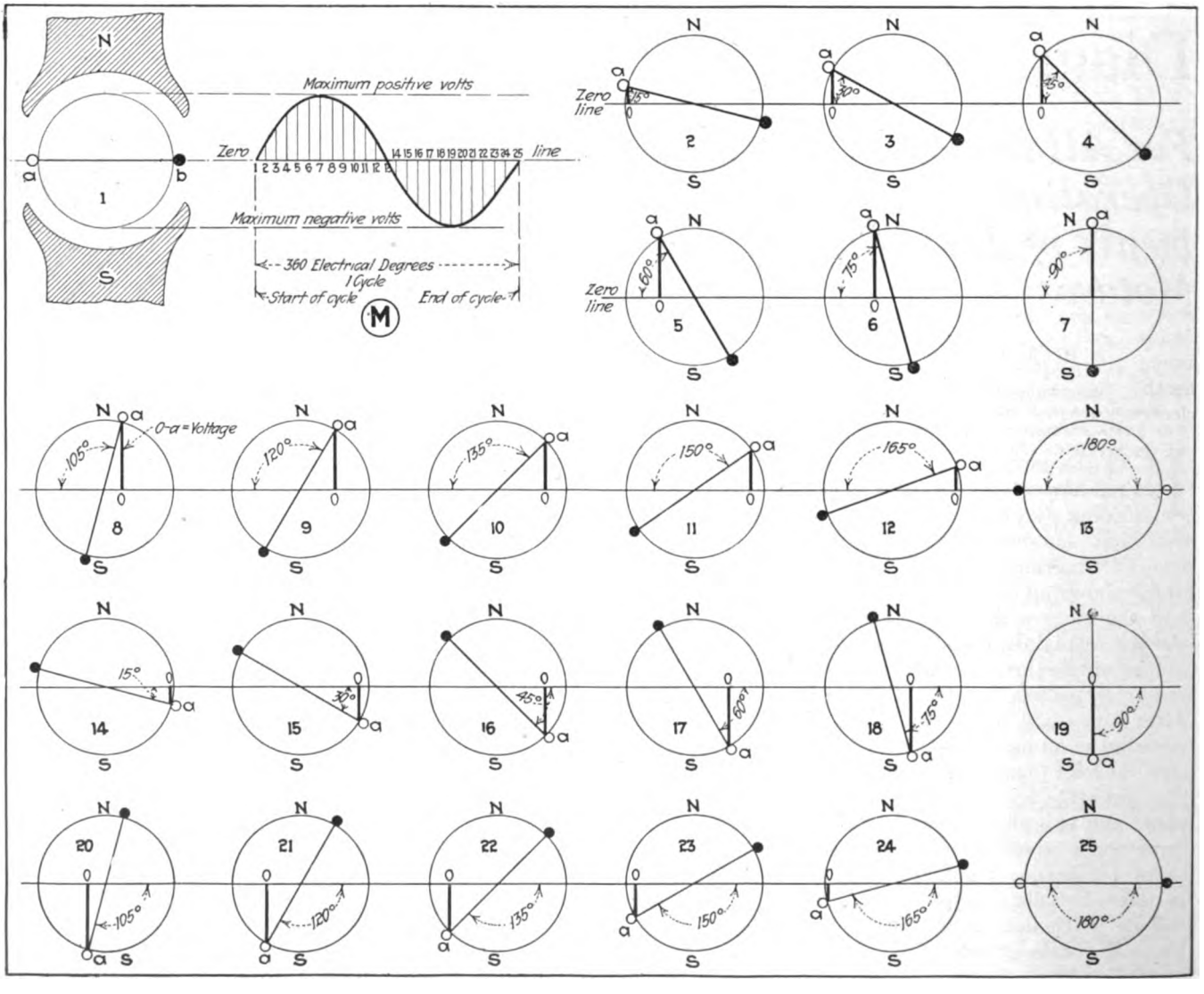
Starting with position No. 1, the conductor is not cutting any lines of force and hence there is no voltage generated, as the conductors are in the neutral region.

The values of the voltage, in the different positions, are plotted in the form of the curve which is shown at *M*. In the second position, the voltage has increased to some extent. In the third position, the conductor has moved through 30 degrees and the voltage has become equal to half of the maximum voltage. Thus the voltage increases through Nos. 4, 5 and 6, and at position 7 the voltage is the maximum voltage, as shown by the curve in *M*. In position 8 the voltage now starts to drop off. It drops off until position 13 is reached, when the voltage equals 0. When conductor *a* passes below the zero line, it enters a magnetic field of opposite polarity; in other words, it passes now to a south pole. This will change the direction of the induced voltage.

In position 14, the voltage has started to be negative, and it continues in a negative direction until it reaches position 19, when it is maximum in the negative direction. From then on it decreases until it finally reaches 0 again, in position 25.

This illustrates the generation of

Fig. 1—Operating principle of the single-phase machine.
This shows the simplest kind of two-pole generator. The conductors *a* and *b* revolve inside the poles. The voltage at any instant is proportional to the line *o-a* as shown in positions 1 to 25. At *M* is a curve showing the voltage at each position during a revolution or one cycle.



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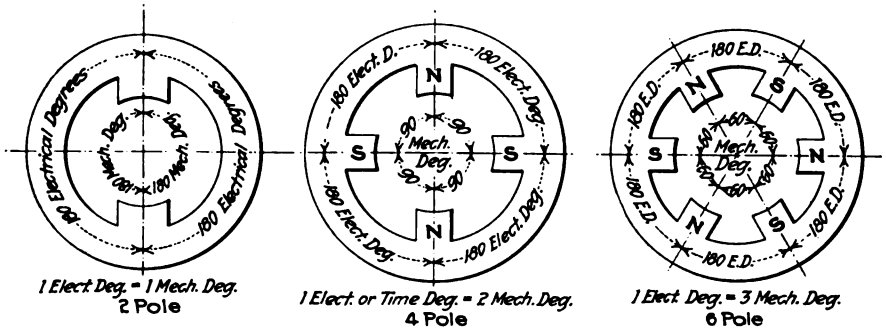


Fig. 2—Space of 90 electrical degrees with various numbers of poles.

As the number of poles increases, 90 electrical degrees becomes less and less in mechanical degrees. A span of 360 electrical degrees covers exactly two poles regardless of the number of poles in the machine.

single-phase voltage, which in modern generators closely follows a sine curve. The entire change from position 1, when the voltage is zero, through the maximum positive, zero, maximum negative and back to zero, is called one cycle. A cycle can be defined as one complete change in voltage. This change takes place as the conductor is passing by two poles. One cycle covers 360 electrical degrees, while one revolution of the conductor on its armature covers 360 mechanical degrees. Therefore, it follows that in a two-pole machine there is one cycle per revolution and one mechanical degree equals one electrical degree. However, on a four-pole machine, there will be two cycles per revolution and, therefore, one mechanical degree will equal two electrical degrees. Likewise, in a six-pole machine, there will be three cycles per revolution and one mechanical degree will equal three electrical degrees. This is illustrated in Fig. 2. Here three machines are shown, having respectively 2, 4 and 6 poles. In all cases, regardless of the number of poles, the distance between the center lines of adjacent north and south poles equals 180 *electrical* degrees.

The frequency of a circuit equals the number of cycles per second. The frequency, therefore, is equal to r.p.m. divided by 60, multiplied by the number of pairs of poles.

From this reasoning, if we know the number of pairs of poles and the frequency, we may get the revolutions per minute. In Table I are given values for revolutions per minute for any number of poles up to 36, at 25, 30, 40, 50 and 60 cycles. This table also shows a formula for finding the speed, number of poles or frequency when any two of the three values are given.

The foregoing has dealt with the operation of generators only but the principle of spacing the coils is the same also for motors and the principle shown in Fig. 2, to provide the proper spacing of North and South poles must be used when drawing any winding.

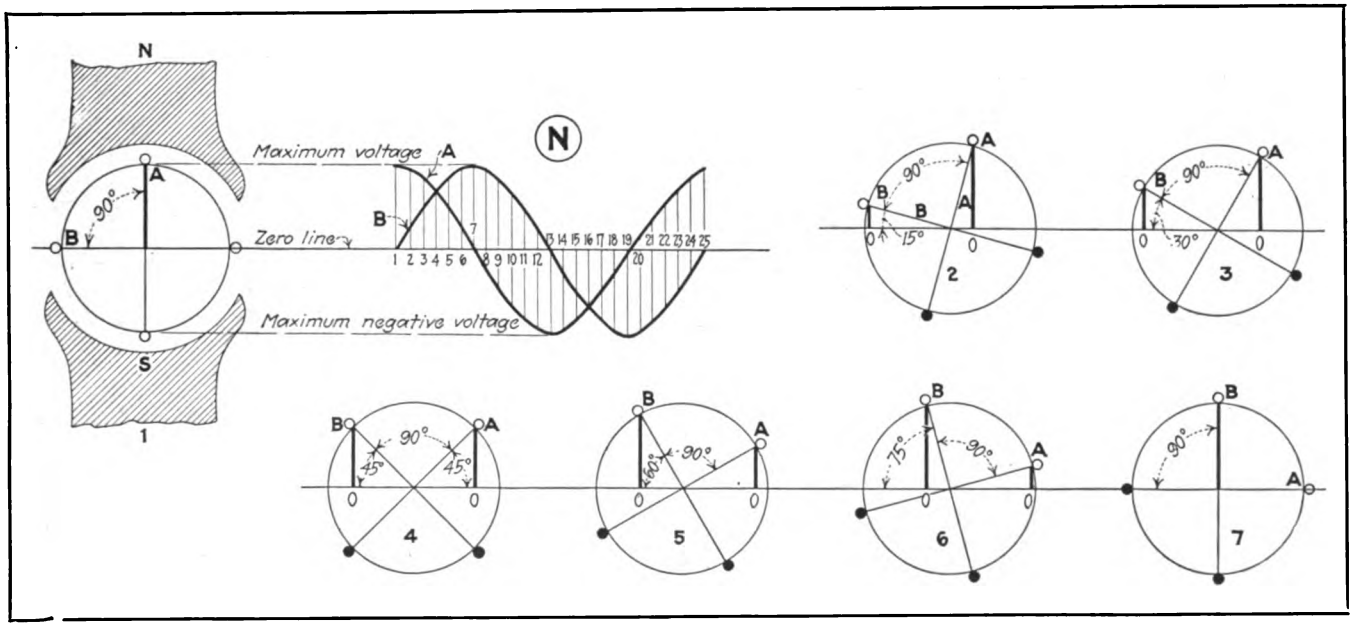
Fig. 3—Operating principle of the two-phase machine.

This is a two-pole machine with two coils which are not connected together but are fixed 90 mechanical degrees apart. The voltage generated by each coil is the same as that generated by the coil in Fig. 1. The voltage generated by *B* however reaches its maximum after the voltage generated by *A*. The voltage of both coils during a cycle is shown at *N*. With a four-pole machine the coils would be only 45 mechanical degrees apart. With a six-pole machine they would be 30 mechanical degrees apart. Fig. 2 illustrates this clearly.

How to Draw a Developed Single-Phase Winding

One of the best ways to draw a complete winding is illustrated in Fig. 4. This shows every coil and the stub connections, as well as the jumpers and the line leads. This particular winding diagram is for a four-pole, single-phase machine in which the coils are connected in series. In order to construct such a diagram, three circles are drawn as shown at *M*, in Fig. 4. Between circles *D* and *E* are drawn the radial lines to show the position of the slots. In this winding there are 12 slots, and therefore the lines are drawn at 12 points. It will be noted that a full line and a dotted line are drawn at each point. The full line represents the top side of a coil, while the dotted line represents the bottom side of a coil. After these coil sides are drawn, they are connected to form coils as shown at *N*, in Fig. 4. At *O* is a sketch of a coil which is shown as a diagram at *N*.

Before it is known which of the coil sides should be joined together to form the first coil, the coil pitch must be determined. What is called "full pitch" equals the number of slots divided by the number of poles. When a coil has full pitch it spans



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exactly the full width of one pole. In this case there are 12 slots and 4 poles, and consequently the full pitch equals 3. Sometimes a pitch greater or less than full pitch is used and this is called a "chorded" pitch. After the pitch is known the coil sides are joined together as shown at *N*. This is repeated around the diagram until each top coil side is connected to one bottom coil side. After all the coils are joined, then two leads are put on each coil as shown at *N*.

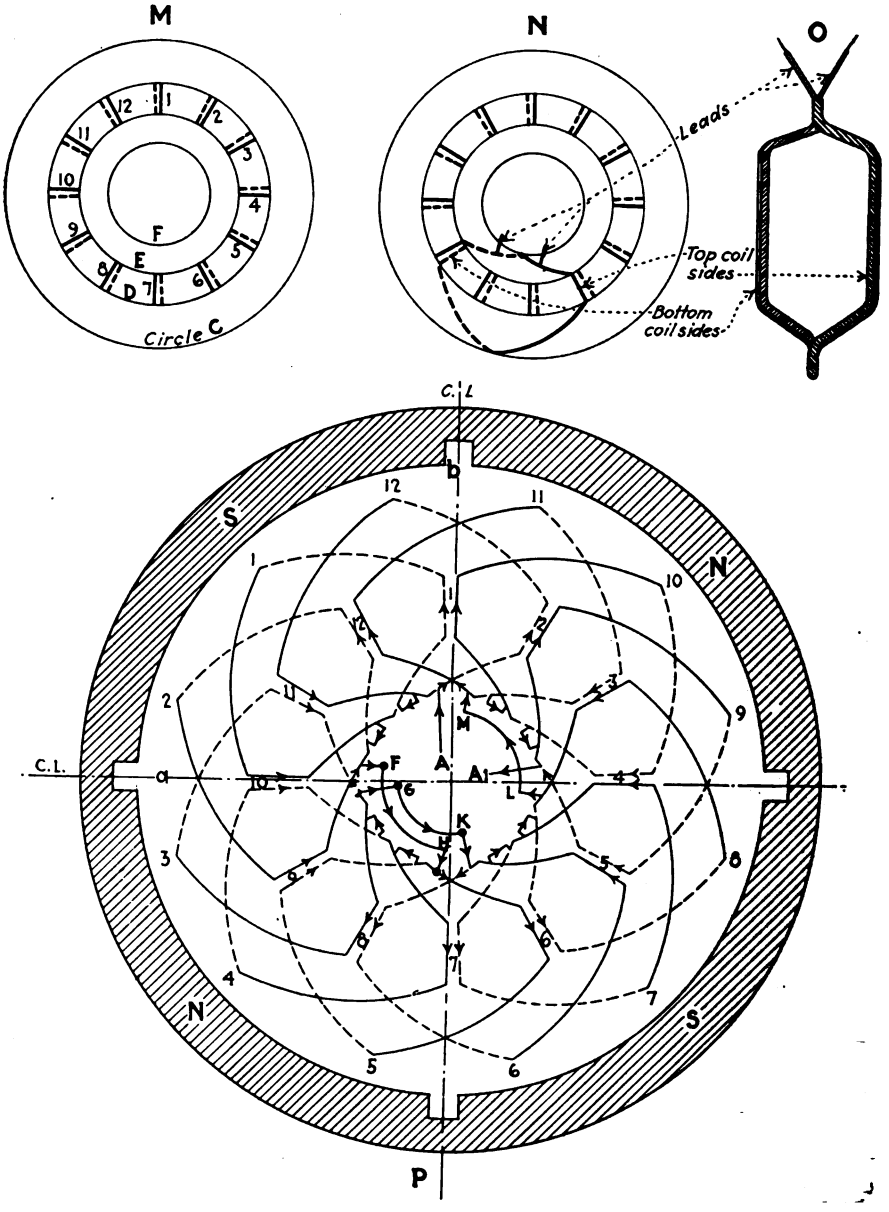
The next step is to connect these coils into groups (pole-phase groups). As this is a single-phase machine, all of the coils forming one pole (North or South) are in one group. As there are 12 coils and four poles, this gives three coils per group. Therefore, starting at any point, connect three coils in a series to form a group. For instance, coils 11, 10 and 9 are connected in series. In connecting up this group, the bottom lead of coil 11 is connected to the top lead of coil 10. Similarly, the bottom lead of coil 10 is connected with the top lead of coil 9. Likewise, coils 8, 7 and 6 are connected into a group and two other groups are formed with coils 5, 4 and 3 and coils 2, 1 and 12.

We now have 4 groups with 8 leads, 4 top and 4 bottom leads. Now all conductors under the space which would be spanned by one pole will have the current induced in them in the same direction. Therefore, we may put arrows upon the conductors in the slots, as shown in Fig. 4, representing the direction of the currents. This should be done first for the *top* conductors. For instance in slots 12, 1 and 2, the arrows on the top conductors all point outward. Following this, in slots 3, 4 and 5 they point inward. This is reversed in every three slots entirely around the diagram. This will give four poles. The direction of the arrows in the bottom conductors depends on the pitch of the coils. After the top arrows are put on, the direction of current in the coils is traced around to the bottom conductors and the arrows are put on in the proper direction.

The problem now is to connect the groups in series, so that starting at lead *A*, we may follow through the winding in the direction of the arrows and come out on lead A_1. Letting this lead *A* be the beginning of the circuit, then the lead *F* is the end of the first group and as the current flows in toward *A*, then it flows out at *F*. Now on the next adjacent group (coils 3, 4 and 5) there are two leads, *G* and *H*. According to the direction of the arrows already put on, the current in the *G* lead is coming out and that in the *H* lead is going in. Therefore, by connecting lead *F* to lead *H*, groups 1 and 2 will be put in series and the current will flow in the proper direction. Likewise, lead *G* should be connected to lead *K* in group 3 (coils 6, 7 and 8), and lead *L* in group 3 should be connected to lead *M* in group 4. This will connect all four groups in series, leaving as line leads *A* and A_1, both of which are top leads.

Fig. 4—How a developed winding diagram is laid out.

This type of diagram shows every coil and connection. This particular diagram is for a four-pole single-phase series winding. There are twelve slots and the coils have a full pitch of 1-and-4. A simpler type of diagram is shown in Figs. 6 and 7.



Single-Line Diagram and Parallel Connections

There is a simpler type of diagram which may be used in place of the developed diagram just described. This simpler diagram represents all the coils of one group by a single line. This type of diagram is explained in Fig. 6. It is discussed fully under two-phase and three-phase windings later on. A full discussion is omitted here because the majority of work in a repair shop is on two- or three-phase windings, and it is included under discussions of those windings to avoid referring back to single-phase windings.

For the same reasons parallel connections are not discussed here. However, by following the discussion under two-phase windings and consulting Fig. 9 it is easy to see how single-phase windings may be connected in parallel.

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Principle of the Two-Phase Machine

A two-phase generator or motor consists of two single-phase windings mounted in one machine. The principle of operation is illustrated in Fig. 3. Here four conductors are shown instead of two conductors as were shown for the single-phase machine in Fig. 1. The coils are mechanically arranged so that any one coil of each phase is 90 electrical degrees from the corresponding coil of the other phase. The voltage generated by each of the coils represented respectively by conductors *A* and *B* goes through the same cycle as the voltage generated for the single-phase coil in Fig. 1. The voltages in *A* and *B*, however, are generated at different times, that is to say, the voltage in *A* is a maximum while the voltage in *B* is zero. This is the condition shown in position 1 of the circle between the pole pieces. Then as the conductors revolve to position, shown in the circle marked No. 2, the voltage in *A* diminishes while that in *B* increases. Both voltages are at this instant in the positive direction. Passing on to positions 3, 4, etc., voltage *A* continues to diminish while voltage *B* increases. In position 7 voltage *A* has decreased to zero while voltage *B* has reached the maximum value. The conductors in position 7 have revolved through an angle of 90 degrees. After passing the position shown in 7, a negative voltage will be generated in *A*, while *B* will still have a positive voltage but it will be decreasing in value. After passing the position shown in 7 the voltage in *A* will increase until it is a maximum in the negative direction at which time the voltage in *B* will have decreased until it is zero. Then the voltage in *A* will tend to decrease while that in *B* begins to increase, both in the negative direction. Finally *A* will reach a zero value while *B* will be maximum in the negative direction. Then *A* will begin to increase positively while *B*, which is of a negative value, will begin to decrease and when the conductors have passed through 360 electrical degrees they will again reach the point shown in position 1. The curves at *N* show the voltages which are generated in the two phases during one cycle. It is clearly seen that the position of these voltages with reference to each other depends entirely on the physical relation of the coils. The corresponding coil of one phase should be 90 electrical degrees behind the corresponding coil of the

Table I.—Speed of A. C. Motors at Various Frequencies

No. Poles	No Load Speed (R.P.M.) at Different Frequencies (Cycles per Second)				
	60	50	40	30	25
2	3,600	3,000	2,400	1,800	1,500
4	1,800	1,500	1,200	900	750
6	1,200	1,000	800	600	500
8	900	750	600	450	375
10	720	600	480	360	300
12	600	500	400	300	250
14	514	429	343	257	214
16	450	375	300	225	187
18	400	333	266	200	166
20	360	300	240	180	150
22	327	273	218	163	136
24	300	250	200	150	125
26	277	230	184	138	115
28	257	214	165	128	107
30	240	200	160	120	100
32	225	187	150	112	94
34	212	176	141	106	88
36	200	167	133	100	83

These values are obtained from the general formula F = (R.p.m. ÷ 60) × (No. poles ÷ 2) where R.p.m. is the synchronous speed. From this formula are derived the following equations which are directly applicable in motor winding:

For 60 cycles:	R.p.m. = 7,200 ÷ No. poles	No. poles = 7,200 ÷ R.p.m.
50 cycles:	R.p.m. = 6,000 ÷ No. poles	No. poles = 6,000 ÷ R.p.m.
40 cycles:	R.p.m. = 4,800 ÷ No. poles	No. poles = 4,800 ÷ R.p.m.
30 cycles:	R.p.m. = 3,600 ÷ No. poles	No. poles = 3,600 ÷ R.p.m.
25 cycles:	R.p.m. = 3,000 ÷ No. poles	No. poles = 3.000 ÷ R.p.m.

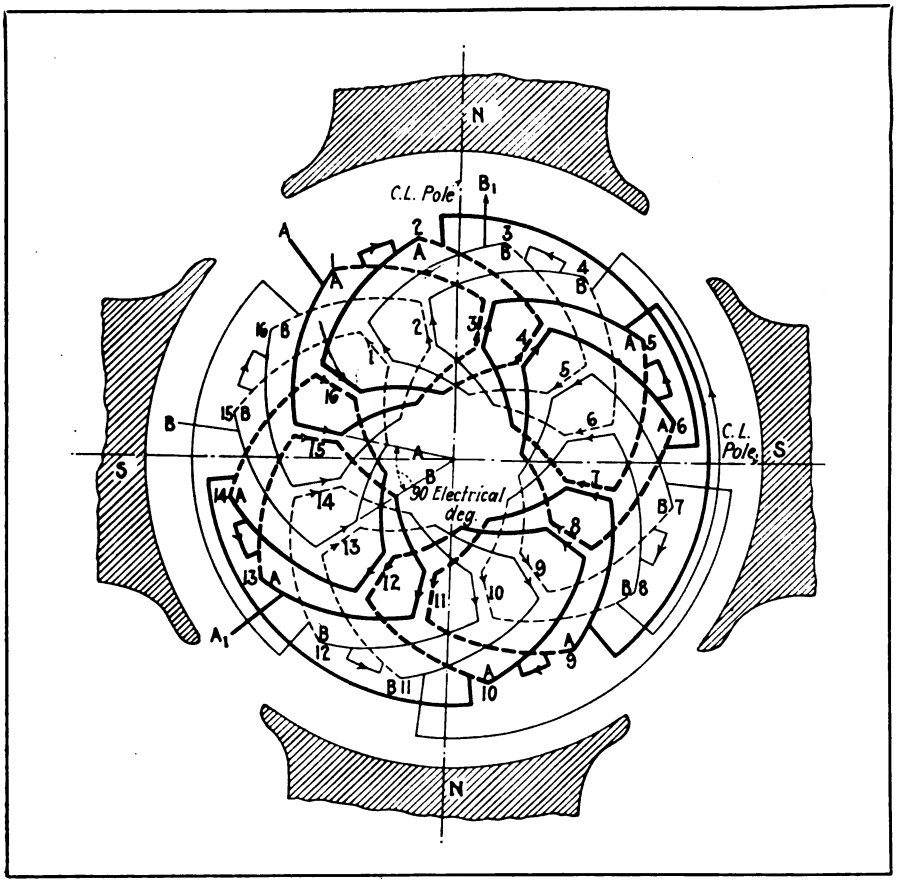


Fig. 5—Developed two-phase diagram.

This was laid out as shown for the two-phase winding in Fig. 3. The heavy lines show the *A* phase. The diagram is for four poles and sixteen slots. There are four slots per pole and the coils have full pitch of 1-and-5. There are two slots per pole per phase, therefore, each group has two coils. The groups are connected in series.

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other phase. On a two-pole machine this means that they should be 90 mechanical degrees apart. On a four-pole the coils should be arranged so that a certain coil of one group is 45 mechanical degrees from the corresponding coil of the next group (see Fig. 5). For a six-pole machine the first coil of one group should be 30 degrees mechanically from the corresponding coil of the next group. This means that for every pole of a two-phase machine there are two groups. For a two-pole machine there are four groups, for a four-pole machine there are eight groups, etc.

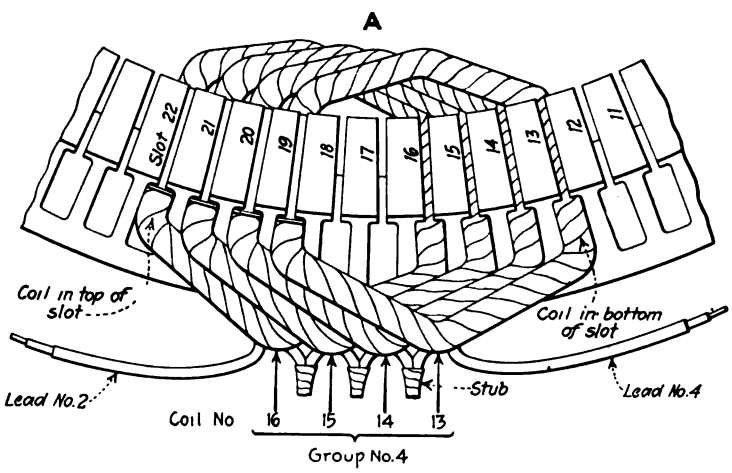
Constructing a Developed Two-Phase Winding Diagram

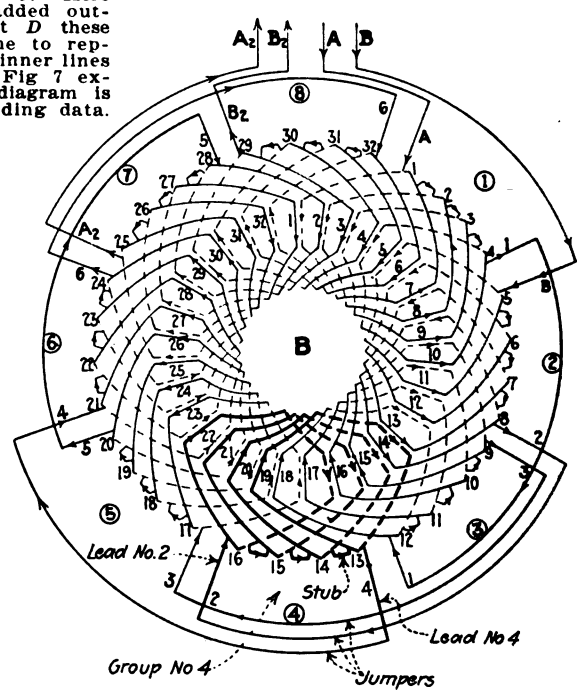
The relation of coils and the groups just mentioned must be remembered when drawing diagrams of two-phase windings. Fig. 5 shows a developed two-phase winding for four poles. There are 16 slots and 16 coils. These are put in at a full pitch of 180 electrical degrees. As there are four poles and 16 slots, full pitch will equal 16 divided by 4 or 4 slots which is a pitch of 1-and-5. We first draw the position of the 16 slots as shown in *M* of Fig. 4. Next we connect up the conductors front and back by means of the curved lines, connecting the top conductor in slot 1 with the bottom conductor in slot 5 to give a pitch of 1-and-5. This is continued all around until all of the coils are shown completed.

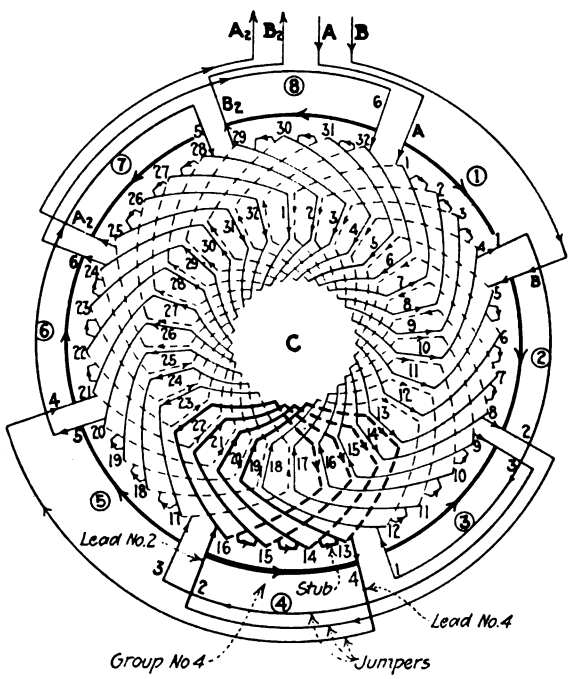
After all the coils are drawn in the next thing to do is to put on the arrows on the top conductors. The top conductors are represented by the full lines. The arrows on the top conductors under the space of one pole must all point in the same direction. As there are four slots per one pole the arrows on the top conductors of four consecutive slots

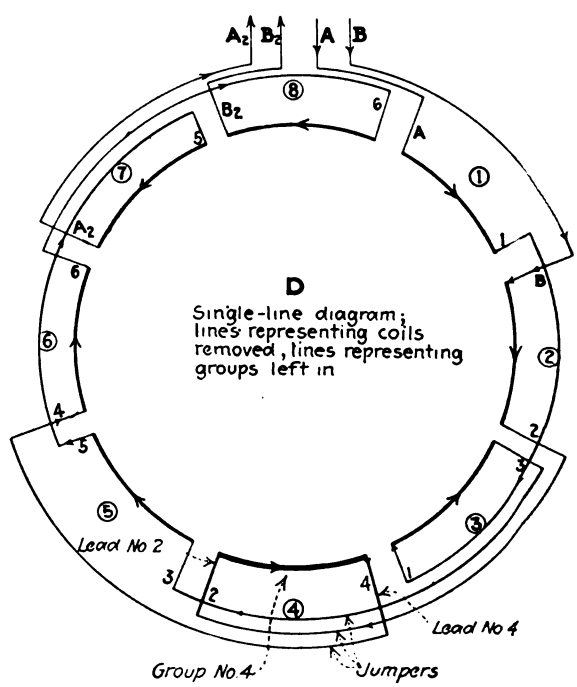
Fig. 6—How a single-line diagram is derived from a developed diagram.

At *B* is a developed diagram. The four coils making Group *H*, shown in heavy lines, are shown at *A*, as they would appear in the stator. The first step in deriving the single-line diagram is shown at *C*. Here heavy lines have been added outside of each group. At *D* these heavy lines are left alone to represent the groups, all the inner lines having been cut away. Fig 7 explains how a single-line diagram is constructed from the winding data.



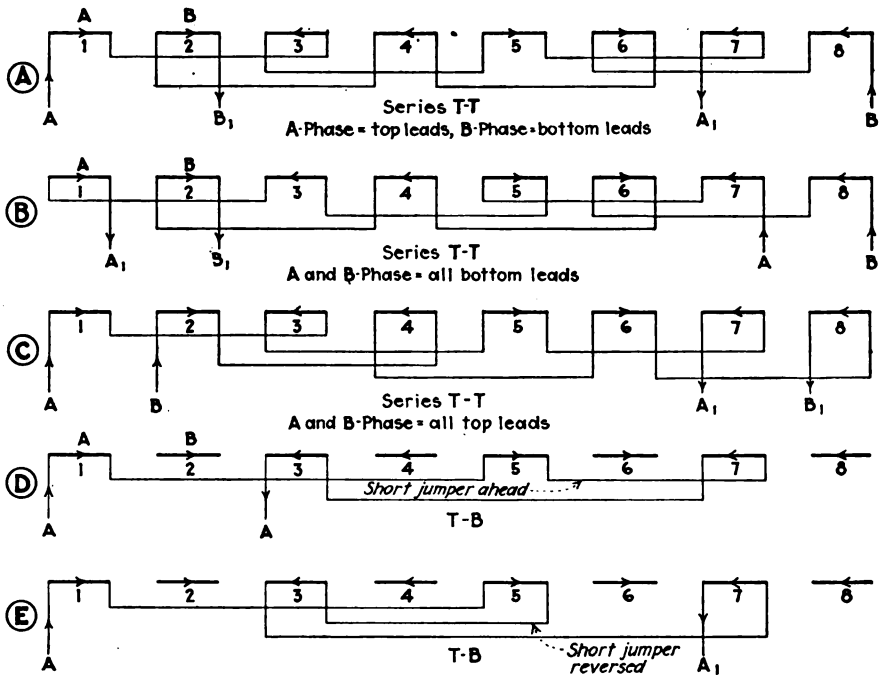






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Fig. 8—Line leads may be put on in several ways.
These drawings show how the lines may be connected to either top or bottom leads provided the polarity of the groups is kept correct. Also at *D* and *E* is shown the difference between placing the short jumper (on a top-to-bottom winding) ahead or reversed.



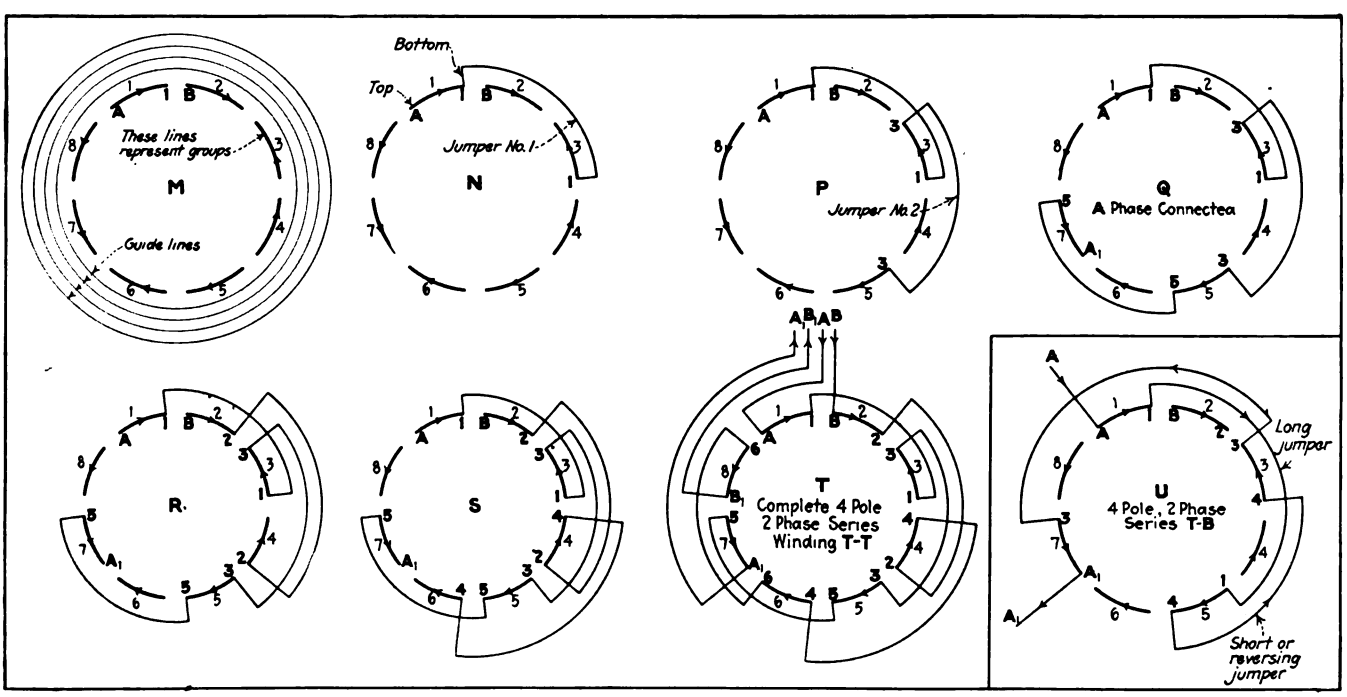
must point in one direction. For instance, the top conductor in slot 1 points outward and the following three top conductors, respectively in slots 2, 3 and 4, also point outward. The arrows on the top conductors in the next four slots point inward and this is repeated until all the slots are covered. After the arrows are put on the top conductors, then the direction of the current is traced around to the bottom conductors and the arrows are put on them also. For instance, the arrow on the top conductor in slot 1 points outward. The bottom conductor of the coil whose top is in slot 1 lies in slot 5. Therefore the arrow on the bottom conductor in slot 5 points inward. This is carried out for all of the bottom conductors.

In a winding which has full pitch, it will be found that the two arrows in any one slot always point in the same direction. However, where a winding has a chorded pitch, the arrows in one slot sometimes oppose each other.

After these arrows are put on, the next step is to connect the coils into groups. There are sixteen coils in this winding and two phases and four poles. Therefore each group will have $16 \div (1 \times 4) = 2$ coils. Therefore the coils are connected together in groups of two. As this is a two-phase winding we know that first one group will belong to the *A*-phase and then the next group to the *B*-phase. In other words, we have two single-phase windings each 45 mechanical degrees apart. The electrical angle between corresponding coils is 90 degrees. For instance, if coil 15 is the first coil of the *B*-phase, then coil 1 is the first coil of the *A*-phase, as these coils are 90 electrical degrees apart or 45 mechanical degrees. This being a four-pole machine, one mechanical degree equals two electrical degrees.

Starting with the top lead of coil 1, all the coils in the *A*-phase are connected together in series. In the diagram these *A*-phase coils are shown by heavy lines. Starting with coil 1, coils 1 and 2 form the first *A*-group. The next *A*-group consists of coils 5 and 6. In order to keep the current flowing according to the arrows which have been put on the slots, the bottom lead of coil 2 is connected to the bottom lead of

Fig. 7—How a single-line diagram is constructed.
This is for a four-pole, two-phase motor. Drawings *M* to *T* show the steps in laying out a top-to-top or short-jumper connection. Drawing *U* shows one phase of a winding with top-to-bottom connections or long jumpers.



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coil 6. Coils 9 and 10 are the third group in the *A*-phase. The top of coil 5 is connected to the top of coil 9 Then the bottom of coil 10 connects to the bottom of coil 14, which together with coil 13 forms the fourth group. This completes the four groups of the *A*-phase.

Then the four groups of the *B*-phase are connected in the same manner. After this four leads are brought out, two for each phase.

In the foregoing discussion the groups nearest together were tied together in series. For instance the first *A*-phase group was connected to the second *A*-phase group. In practice this is done by means of a wire called a jumper. This is called a "short" jumper when it connects adjacent groups of the same phase as in this discussion. There is another type of winding however which employs a "long" jumper which skips the next group of the phase and connects to the third group. The difference between these two kinds of jumpers and the advantages of each are discussed in more detail following the explanation of the single-line diagram.

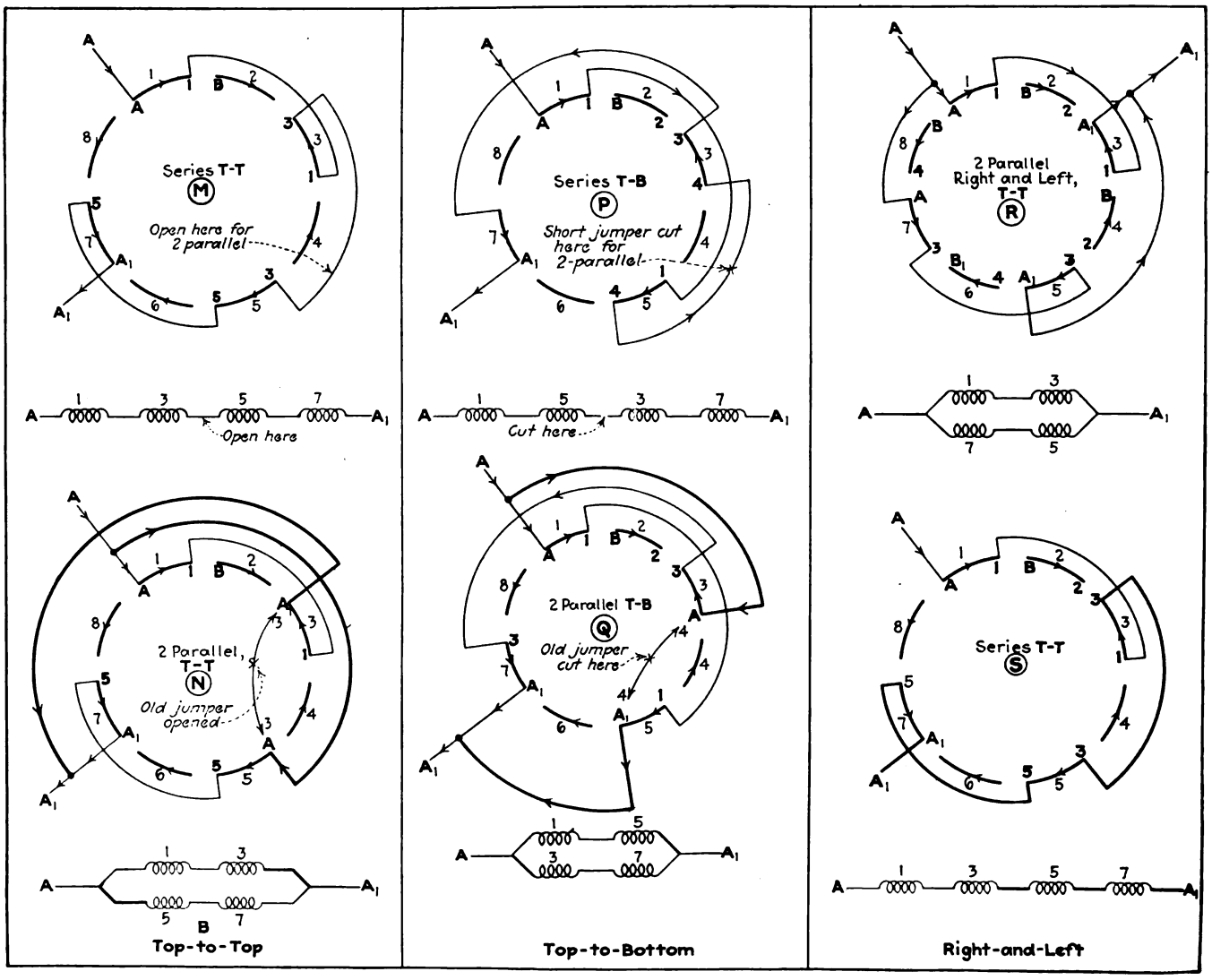
How to Draw the Single-Line Simplified Diagram

A single-line diagram much simpler than those shown in Figs. 4 and 5, can usually be used. The diagrams in Figs. 4 and 5 are called developed drawings as they show each coil and the coil pitch. This type of drawing is tedious to make, especially when the number of slots is large. Furthermore, one single-line diagram will cover quite a number of different windings. One diagram may be used for any motor having a certain number of groups regardless of the number of coils per group and the pitch of the coils. This last information may be kept in a separate place.

The method in which the single-line diagram is formed from the developed diagram is shown in Fig. 6. The diagrams in this figure are for a two-phase, four-pole series winding of 32 coils having a pitch of 1-and-7. There are eight pole-phase groups and four coils per group. The diagram at B is the ordinary developed diagram for this winding. One group, No. 4, is shown in heavy lines. At *A* is a drawing of four coils placed in a stator and connected together as they would be on an actual motor. This group is represented by the heavy lines in *B*. Now to evolve the single-line diagram from this developed diagram, *A*, heavy lines are drawn across the groups as shown in *C*. In other words, a single heavy line is drawn covering coils 1, 2, 3 and 4. Likewise another line covers coils 5, 6, 7 and 8, and so on around the diagram. *(Continued on page 467.)*

Fig. 9—How two-parallel windings are obtained from series connection.

These diagrams are all for four-pole, two-phase motors. The heavy lines show the leads which have been changed to get the connections given in the lower drawings. Diagrams *M* and *N* are for short jumpers and top-to-top connections.. Diagrams *P* and *Q* are for long jumpers connected top-to-bottom. At *R* is a "right-and-left" two-parallel connection, while *S* shows the changes necessary for a series connection.



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A General Summary of

Industrial Lighting Regulations

That Are Included in Existing Codes Together with the Present Tendencies Toward Future Legislation

By G. H. STICKNEY

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DURING the last decade lighting codes, having as their object the promotion of safety and protection of the public, have been adopted in the various states of the Union. Previous to 1913, some legislation had been undertaken, but was apparently proving ineffective. The difficulty seems to have been in the inability to define particular characteristics of lighting in terms which were at the same time reasonably definite and fundamentally sound. Some of the earlier regulations were made too drastic by specifying particular equipments or establishing limits which incurred considerable injustice, without insuring the accomplishment of the desired object. Other regulations simply required "adequate" light, which in the absence of an established standard of adequacy left too much to personal judgment.

There was no general understanding of the fundamental principles of lighting, even among engineers, until the Illuminating Engineering Society provided a medium for discussing and recording lighting information. And even yet the elements of light quantity and quality are not widely understood by the public or its legislative representatives.

Considering these conditions, the effectiveness and fairness of recently adopted regulations are truly remarkable. While these regulations are far from complete it seems to be rather generally conceded that they have materially improved conditions, and this without serious injustice to anyone. Practically all of the recent enactments have been based upon the specifications drawn by the Illuminating Engineering Society.

In their endeavor to be fair com-

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mittees of this society have resisted the pressure on them to put out definite specifications quickly. They have chosen rather to allow liberal limits, until knowledge or experience warranted a more rigid or exact definition. On the other hand, by introducing the foot candle and other reproducible measures this society has established the foundation of determinate limits on which the more exact regulations can be based. Having definite measures which eliminate the really bad cases, it becomes practicable to change the limits by predetermined amounts until the desirable mean is found.

Why There Is Need of Lighting Regulations

That there is a real demand for lighting legislation seems obvious. The problem facing the lighting industry today is not whether or not we shall have lighting legislation, but rather what can be done to guide such legislation along wise lines. Any unnecessary regulations are, of course, to be discouraged. On the other hand to combat all legislation is likely to result in unwise enactment which may not only prove more or less ineffective, but at the same time impose unnecessary hardship on the part of interested groups.

So long as any number of employers provide, through ignorance or false economy, inadequate or glaring illumination, so that employees are exposed to accident hazards or eyestrain, a demand for industrial lighting codes may be expected. So long as a few motorists subject other users of the highways to dangerous conditions, through improper lighting, a demand for motor-vehicle lighting regulations will be felt.

That systems of lighting regulations are likely to be of importance in the future seems apparent from the following tendencies:

(1) Grouping of larger numbers of people together, thus making all safety measures more necessary, if only to avoid panic. (2) Enlargement of buildings and other constructions, which restricts or even excludes daylight, thus necessitating provisions for ample light, either natural or artificial. (3) Increasing night activities.

Industrial Lighting Codes Which Have Been Issued

The Illuminating Engineering Society's Code of Lighting for factories, mills and other work places was first issued in the summer of 1915, a second issue following in 1918 and a third in 1920. It was adopted as an American Engineering Standard in 1921.

Pennsylvania and New Jersey were the first states to adopt the code, and they were followed by New York and Wisconsin. Later, California and Oregon accepted the code, the latter writing many of the details into the law itself. Ohio adopted the code, as a guide to inspectors in 1920, and now Massachusetts will have it in force January 1, 1924. Pennsylvania is at the present time considering minor changes. Several of these states have varied the form to correspond to their local practices, and in some instances slight changes have been made in the provisions. The codes of all these states, however, are essentially the same.

In the latest codes no distinction has been made between daylight and artificial light, on the assumption that daylight will be employed when available, and when this fails to be adequate artificial lighting will be supplied. Especially for sanitary reasons it is desirable to have daylight enter work rooms, but there are many work rooms from which daylight is entirely excluded, as in mines and in basements of larger buildings. It has, therefore, seemed neither necessary nor practicable to provide that daylight shall be supplied.

The general requirement of the American Engineering Standard Code is that traversed spaces in time of use and work in process shall be supplied with light, as specified in the rules.

These rules provide for (1) a certain intensity according to the use, (2) avoidance of glare, suitable diffusion and distribution of light and, (3), exit and emergency lighting.

The intensity rule requires that working surfaces shall have 0.5 to 5 foot candles, according to the nature of the process as described. Five-tenths of a foot candle are required for hallways, stairways and exits, while 0.25 foot candles are accepted for ordinary aisles and passages. For roadways and yard thoroughfares, 0.02 foot candles or about the equivalent of bright moonlight are prescribed.

Intensities of one foot candle and less may be considered as intended principally to facilitate the prevention of mechanical accident, while the higher levels have the added purpose of preventing eye strain. There are unquestionably many classes of work for which five foot candles are not adequate for eye comfort. Such processes, however, require skilled operatives, who are generally able to protect themselves without legal support. Moreover the need of good lighting is so obviously necessary from economic considerations that no regulation seems necessary.

The various grades of work are rather generally described, with some examples to indicate the intent. Thus two foot candles are specified for "Where moderate discrimination of detail is essential—work such as: machinery, assembly work, bench work, fine core making in foundries, cigarette rolling."

There has been some demand for a detailed list of processes corresponding to each grade. Such a list if practicable would undoubtedly facilitate inspection. Several obstacles have arisen to making such a list mandatory; for example, the same process is carried on with varying degrees of fineness in different factories, and for this reason as well as the variation in automatic machinery, gages, and so on, would not always fall in the same class. An extended list, moreover, tends to imply a greater degree of accuracy in classification than some of the experts have thought warranted. Such a list has been incorporated in the nonmandatory section of the American Engineering Standard Code and some of the states are trying out such a list on the mandatory basis. Their experience will probably guide future practice in that respect. Table I compares the intensities specified in the various codes.

The second rule requires that the "lighting, whether natural or artificial, shall be such as to avoid glare, objectionable shadows and extreme contrast, and to provide a good distribution of light." It is further provided that "lamps shall be so installed in regard to height, location, spacing and reflectors, shades or other suitable accessories, as to accomplish these objects. . . . Bare light sources, such as exposed lamp filaments or gas mantles, located within the ordinary field of the worker's vision are presumptive evidence of glare."

Reference is given to a tabular scheme, by which illuminants and accessories are graded with respect to their glare-producing power. Permissible equipments and their locations with regard to the various grades of work are indicated. While apparently more or less complicated,

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this scheme is not difficult to comprehend and apply. It is by far the best means so far discovered for facilitating the interpretation of the rule. There is presented with it a discussion of the various factors affecting glare and an explanation of the derivation and use of the scheme.

The method of rating lighting units as to their glare-producing properties is so novel and logical that it seems desirable to outline briefly here the scheme employed.

Five principal causes of glare are taken into consideration: (1) Brightness of source; (2) total volume of light; (3) location in field of view; (4) contrast with background and (5) time of exposure. The first two factors concern the light source itself; the third factor concerns its location, while the fourth and fifth depend upon the conditions of its use.

All commercial light sources, gas, arc, incandescent and mercury vapor lamps as well as natural light sources, are graded into ten classes which take into account both brightness and candlepower. Table II indicates the classification of tungsten filament lamps with various accessories. Grade I represents the minimum glare while Grade X represents the maximum.

To take into consideration the third factor: namely, location of the light source in the field of view, the diagram in Fig. 1 and Table III are presented. Their use is quite obvious and needs no explanation.

It is apparent that some classes of work are much more exacting than others as to the effect of glare. A given light source in a certain position may be satisfactory for one use and not for some other. Table IV shows these limitations, taking into consideration the factors previously discussed.

The third rule covers exit and emergency lighting, and reads as follows: "The lighting to be provided under Rule 1 in all stairways and exits of factories and in the passageways appurtenant thereto shall be supplied so as not to be subject to failure because of the failure of the room or work space lighting from internal causes, and preferably from an independent connection extending back to the main service entrance for the building. In case of unusual danger which may exist on account of type of building, nature of the work, crowded conditions or lack of suitable exit space, an independent service shall be insured by connecting to a separate source of supply without or within the building." This rule is in general self-explanatory. It is obviously made flexible to conform to local facilities and requires only what is necessary to insure safety.

That continuity of service be maintained is a lighting consideration. How this shall be accomplished is an electrical problem, and in some states is already covered in wiring regulations. The lighting code naturally avoids going far into detail regarding it. The industrial lighting codes have now been in force from five to seven years and have in general become well stabilized. However, manufacturing methods are developing, the lighting art is advancing, and experience is being accumulated as to the enforcement of the code. With all these changes it should be expected that changes in the codes would become desirable.

The industrial lighting codes have unquestionably accomplished much good. It has been the experience of the state commissions that manufac-

Table I—Intensities of Illumination Specified by the Various Industrial Lighting Codes

State	Roads and Yards		Storage		Stairways. Aisles		Rough (1) Mfg.		Rough (2) Mfg.		Medium (3) Mfg.		Fine (4) Mfg.		Very Fine (5) Mfg.		Office Work		Toilets & Washrooms	
	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.	Min.	Rec.
New Jersey	0.02	0.25	0.25	1.00	0.25	2.00	.....	.....	1.25	4.00	2.00	6.00	3.00	8.00	5.00	15.00	3.00	8.00	.....	.....
Penna	0.02	0.25	0.25	1.00	0.25	2.00	.....	.....	1.25	4.00	2.00	6.00	3.00	8.00	5.00	15.00	3.00	8.00	.....	.....
New York	0.02	.....	0.25	.....	0.25	.....	0.50	.....	1.00	.....	2.00	.....	3.00	.....	5.00	.....	.....	.....	0.5	.....
California	0.02	0.25	0.25	1.00	0.25	2.00	0.50	3.00	1.00	4.00	2.00	6.00	3.00	8.00	5.00	15.00	.....	.....	0.5	.....
Oregon	0.02	0.25	0.25	1.00	0.25	2.00	.....	.....	2.00	6.00	.....	.....	3.00	8.00	5.00	15.00	3.00	8.00	1.00	3.0
Wisconsin	0.02	0.25	0.25	1.00	0.25	2.00	.....	.....	1.25	4.00	2.00	6.00	3.00	8.00	5.00	15.00	3.00	8.00	0.5	3.00
Ohio	0.02	0.25	0.25	2.00	0.25	2.00	0.50	3.00	1.00	6.00	2.00	9.00	3.00	12.00	5.00	10.00	.....	.....	0.25	2.00
I. E. S.	0.02	0.25	0.25	2.0	0.25	.....	0.50	5.0	1.00	.....	2.00	.....	3.00	10.0	5.0	20.0	.....	10.0	.....	5.0

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turers generally desire to comply with the regulations, and that failure has been more often due to lack of understanding than to intentional neglect. Large manufacturers usually employ competent engineers and have means available for the study of their lighting problems. Such manufacturers, in order to secure manufacturing economies, ordinarily provide better lighting than is legally required. The worst offenders are the smaller manufacturers, especially what is known as the "sweatshop" class.

When a single individual has a wide variety of functions, he has little opportunity of spending much time informing himself on any one —and lighting seems to be commonly overlooked. This is the group for which the codes are really needed, and many of those in it have expressed appreciation for economic gains called to their attention, in the endeavor to secure their compliance with the code. This leads to the conclusion that ordinarily the enforcement of the code can best be accomplished by educational rather than by arbitrary methods. Excellent results have been obtained in several states where the educational method predominated. There are, of course, some instances of abuse. A few inspectors apparently think they can make a better showing by criticising a few large manufacturers for technicalities than by correcting serious conditions existing in a large number of small shops.

School Lighting Codes Were Modeled After Industrial Codes

The School Lighting Code is a later development than the industrial. In general it has followed similar lines and as far as practicable the provisions have been patterned after those of the industrial code.

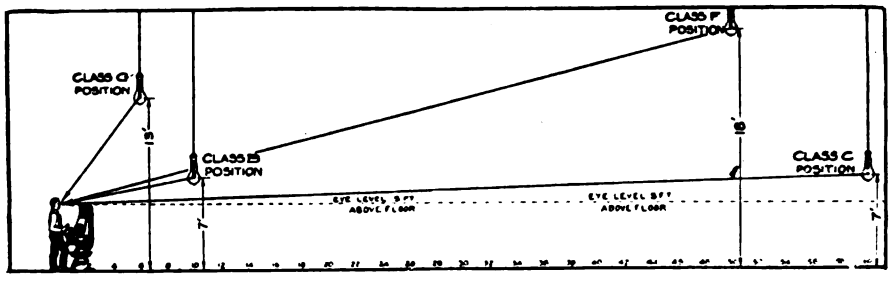


Fig. 1.—Diagram illustrating typical positions given in the chart of field of view. (See Table III.)

The school is more essentially a daylight plant, so that regulation of daylight necessarily takes a more predominant place. The control of daylight is more a matter of building construction and it is no simple problem to make specifications applicable alike to the large school in a crowded section of a city, to the country school house, and to all school buildings between these extremes.

In the city it is often impracticable to prevent the obscuration of daylight by tall buildings, which may be erected after the school is completed. The Illuminating Engineering Society's code was issued in 1918. In 1921 Wisconsin adopted a code based upon it.

In New York State compliance with the I. E. S. code is required of all schools receiving state aid. With the later experience gained the I. E. S. Code is now being revised for submission to a sectional committee of the American Engineering Standards Committee under the joint sponsorship of the American Institute of Architects and the Illuminating Engineering Society.

The school lighting code requires that when in use during daylight hours the rooms in which pupils study or do other work shall be provided with natural light, and when daylight fails they shall be provided with artificial light. In either case the light shall conform to the detailed rules. All other rooms and spaces may have either natural or artificial light, provided the rules set forth below are observed.

Rule 1 specifies the level of illumination required, and recommends that certain higher values be provided.

Rule 2 calls for the avoidance of harmful glare, objectionable shadows and extreme contrasts, it being pointed out that exposed lamp filaments and mantles, as well as sky areas in the field of view, are presumptive evidence of glare. It is required that the seating arrangements be such as not to compel pupils to face windows. Reference is made to a classification of the causes of glare similar to that applied to the code of lighting for mills, factories and other work places.

Rule 3 treats of the distribution of light, which must be reasonably uniform. For artificial lighting it is required that the variation on desk tops and other work places shall not exceed four to one.

Rule 4 specifies the color and finish of the interior, requiring walls with a reflection factor of 35 per cent to 50 per cent and ceilings of such a character as to reflect at least 65 per cent of the light.

Switching and controlling apparatus, exit and emergency lighting are discussed in the next two rules, while Rule 7 makes necessary a systematic inspection and maintenance service.

The concluding paragraph states that blackboards shall be illuminated and located with respect to light sources, so as to avoid glare; that they shall have dull rather than glossy surfaces and not be placed be-

Table II—Classification of Tungsten Lamps with Globes and Reflectors from the Standpoint of Glare

	Watts.					
	10 to 25	40 to 60	75 to 100	150 to 200	300	500 to 1,000
	Grade.	Grade.	Grade.	Grade.	Grade.	Grade.
Bare lamps	VI	VII	VIII	IX	IX	X
Frosted lamps or frosted globes	II	III	VI	VII	VIII	.....
8-inch opal globes [1]	I	I-II	II-IV	IV-VI	.....	.....
12-inch opal globes [1]	.....	.....	II-III	II-V	IV-VI	VII-VIII
16-inch opal globes [1]	.....	.....	.....	II-V	IV-VI	V-VII
Flat reflectors—filament visible	VI	VII	VIII	IX	IX	X
Dome reflectors—steel or dense glass:						
Filament visible from working position.	VI	VII	VIII	IX	IX	X
Filament not visible from working position	I	I	III	III	IV	VI
Bowl reflectors—steel or dense glass:						
Filament visible from working position.	VI	VII	VIII	IX	IX	X
Filament not visible from working position	II	II	III	IV	VI	VII
Dome reflectors—bowl-enameled lamps	.....	.....	IV	V	VI	VI
Semi-inclosing units [1]	.....	.....	III-IV	IV-VI	IV-VII	VI-VIII
Totally indirect lighting [1]	.....	.....	I-II	I-II	II	III
Semi-indirect bowl [1]	.....	.....	I-III	II-III	II-IV	III-VI

[1] Where a range is given, the best grade, that is the lowest, applies to globes that are evenly luminous, and the poorest to globes which have a decidedly bright spot in the center.

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tween windows which are only a few feet apart.

Since the welfare of the coming generation is involved, it is to be hoped that a good code will be actively applied. Pupils pursue a task only through the learning period, while a worker often continues for many years after skill is acquired. It follows that the pupil requires better light for a corresponding operation. Unfortunately the practice, in the past at least, so far as artificial lighting is concerned, has been to provide the pupil with much poorer light. There has been a very considerable improvement in many places during the last two years, and the indications are that the importance of school lighting is becoming more and more generally appreciated by school boards. Therefore, we can anticipate accelerated progress in the future.

Trends Likely To Be Followed in Future Legislation

The codes and regulations already adopted will undoubtedly be changed from time to time, to meet changing conditions and take advantage of developments in the lighting art, but no radical changes seem likely at the present time.

Undoubtedly codes will be adopted to regulate the lighting in other fields: for example, lighting of auditoriums and assembly rooms, traffic signal lighting, general exit lighting, lighting of subways, tunnels, mines, and so forth.

On the other hand, such legislation usually proceeds where public necessity dictates. Regulations are not likely to be demanded wherever it is the general practice of lighting to provide for safety. Educational work toward this promotion will unquestionably do much to minimize the extension of compulsory regulations.

Owing to lack of a general understanding of the fundamental features of light, and the universal confidence that "seeing is believing," the conclusions of laymen regarding light are often erroneous. It is probably because of this that optical illusions are the most deceiving. All of which points to the necessity of skilled advice and caution in the enactment of lighting legislation.

On the other hand, people have learned to distrust legislation which is prescribed by representatives of an affected group, because of the liability to prejudice in favor of the related business interests. Fortunately, in the recent proposals for lighting regulations it has been possible to diversify the interests in such a way that they counteract each other. The illuminating engineering committees responsible for specifications have been composed of light users as well as the various producing groups; the employee as well as the employer; the pedestrian as well as the automobile driver.

As an example of the sort of legislation which results when the expert is not consulted, there may be mentioned the locomotive headlight laws passed in a number of states ten or fifteen years ago. These regulations merely specified the amount of light to be used, without any mention of the other characteristics of the equipment. Incidentally, the amount specified was several times as much as is employed in the better practice of today, and therefore required an unnecessarily large expenditure on the part of the railroads. In fact, the laws as written did not definitely specify any useful effect. Fortunately, the railroads in certain western states did interpret them so as to be useful on single-track lines, not equipped with block signals. Such a headlight was condemned by all leading experts as liable to introduce serious hazard when used on double- or four-track roads, and under certain conditions likely to produce incorrect signal readings. A serious situation was developing between the railroads and the state authorities when with its war emergency powers the Interstate Commerce Commission secured jurisdiction and succeeded in securing the withdrawal of the practice urged by the states. While its specification was not accurately descriptive the adoption and acceptance of the incandescent headlight in a standardized form solved the problem for the present.

We are not free today from the danger of unwise regulations. In the writer's opinion the best way to avoid them when threatened is to forestall them with regulations which are fair and definite. In case of doubt, *(Continued on page 469)*

Table III—Chart of the Field of View Illustrated in Fig. 1

Height above floor, in feet.	Horizontal distance of light source from observer, in feet.														
	1	2	3	4	6	8	10	12	16	20	25	30	35	40	50	60 and up.
6.5 or less	[1]A	[1]A	A	A	A	A	A	A	A	A	A	A	B	B	B	B
6.5 to 7	G	E	D	C	C	B	B	B	B	B	B	B	B	B	B	C
7 to 8	G	G	F	E	D	D	C	C	C	C	C	C	C	C	C	D
8 to 9	G	G	G	F	F	E	D	D	C	C	C	C	C	C	C	D
9 to 10	G	G	G	G	F	E	E	D	D	C	C	C	C	C	C	D
10 to 11	G	G	G	G	G	F	E	E	D	D	C	C	C	C	C	D
11 to 12	G	G	G	G	G	F	F	E	D	D	D	C	C	C	C	D
12 to 13	G	G	G	G	G	G	F	E	E	D	D	D	C	C	C	D
13 to 14	G	G	G	G	G	G	F	F	E	E	D	D	D	C	C	D
14 to 15	G	G	G	G	G	G	G	F	E	E	D	D	D	D	C	D
15 to 16	G	G	G	G	G	G	G	F	F	E	E	D	D	D	C	D
16 to 17	G	G	G	G	G	G	G	G	F	E	E	D	D	D	C	D
17 to 18	G	G	G	G	G	G	G	G	F	F	E	E	D	D	D	D
18 to 19	G	G	G	G	G	G	G	G	G	F	E	E	D	D	D	D
19 to 20 and up	G	G	G	G	G	G	G	G	G	F	E	E	D	D	D	D

Table IV—Limiting Grades of Light Source Permissible for Various Conditions and Operations

Classification of position.	Space or work to be lighted.			
	Roadways and yard thoroughfares.	Storage spaces, aisles, stairways, handling coarse material.	Ordinary manufacturing operations.[1]	Offices and drafting work and certain manufacturing operations.[2]
	Limiting grade.	*Limiting grade.*	*Limiting grade.*	*Limiting grade.*
A	VI	V	III	II
B	VII	VI	V	IV
C	VIII	VII	VI	V
D	IX	VIII	VII	VI
E	IX	IX	VIII	VII
F	X	X	IX	VIII
G	X	X	X	X

[1] For the present the limits set in this table can not be rigidly applied to portable lamps used for temporary work, such as setting up machines, repairing automobiles, etc.
[2] Those operations in which workers are seated facing in one direction for long periods of time.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, September, 1923

Using a Steam Hammer to Drive a Tack

REALIZATION that a large crane in a metal-working plant was occupied much of the time in carrying loads weighing only a few hundred pounds, a fraction of its rated capacity, resulted in a rearrangement of the field connections whereby the hoisting speed of the crane could be increased about 40 per cent.

A protest made by the management of another plant over what was considered to be an excessive charge for power service resulted in an investigation which showed that a 50-hp. motor was carrying a load of less than 20 hp., with a power factor of 23 per cent.

Perhaps neither of these conditions could be duplicated in your plant, but do you know by actual test that all of the motors are properly loaded according to their rating? Is there a simple, effective routine for handling inspection and repair work; or are these activities buried in the red tape of a ponderous system of reports and useless routine? Do the requisitions and approvals for material which is to be purchased or withdrawn from the stockroom sometimes cost as much as the material itself?

A steam hammer can be used to drive tacks without any difficulty, but you would never use it for that purpose. With this illustration in mind it might be a good idea to check up some of your equipment and maintenance methods; perhaps they should be replaced.

The Foreman's Part in Safety Work

"WHEN a man is injured I am not particularly interested in what he was doing at the time, but I do make every effort to find out *why* he was hurt. That is, I want to know whether he was careless, or had not been properly instructed in his work, or did not have the proper tools, and so on."

In these words the safety director of a large organization, which comprises a number of separate plants, summed up his method of attacking the problem of accident prevention.

Continuing he said: "At first we used 'scare head' posters showing accidents and some of their results, but we finally decided that these posters did not accomplish as much as we hoped they would. No one gets hurt purposely; so why not find out the real cause of accidents and apply the proper remedy? Many accidents are caused by ignorance on the part of the workman as to the proper way of doing a job, and of the precautions which should be taken. That puts it up to the foreman to see that his men are given the proper instructions for doing the work and for protecting themselves from injury. It's the foreman's job to know these things; that is one reason why he is foreman. Since we began to hold the foremen responsible for the safety of their men, the number of accidents due to ignorance and other preventable causes has been very materially decreased."

For the sake of more effective administration, safety work is handled through a central organization from which each of the various plants of the company purchases accident insurance at a rate which is about 67 per cent of that charged by the standard insurance companies. Common-sense methods, an example of which was given above, have been so successfully applied that during the past ten years the losses have averaged about 29 per cent, so that there has been accumulated in the insurance fund a reserve of over $700,000. This means, of course, that serious and fatal accidents have been reduced to a very low figure. This also indicates the key position which the foreman holds in almost every works.

Don't Forget the Business Side of Repair Work

A VISITOR in the plant of one of the largest motor and electrical equipment repair shops in this country saw a good-looking motor lying on the junk pile. In reply to the question as to why this motor had been junked the superintendent replied: "It isn't worth repairing. We could not sell that motor for enough to pay for the labor and material required to put it in first-class condition; therefore we will save money by junking it."

This superintendent is a good business man as well as an expert in the rebuilding of electrical equipment, and his answer to what appeared to be a sensible question should be of interest to everyone who has anything to do with repair work. It is safe to say that in nine out of ten industrial plant repair shops this motor would have been reconditioned without any question as to its real value after the work was done. Doubtless there would be careful consideration of the type of winding and insulation to be employed, good bearing metal would be used for the bearings, and other questions relating to the technical side of the work would be raised and decided with painstaking care. But the simplest question of all: "Is it worth doing?" probably would not be thought of.

The reason for this is largely due to the fact that in many repair shops the technical side of the work completely overshadows the economic side. The cost of rewinding a motor, say, may not be accurately known or, if careful cost records are kept, the information which they contain may be buried somewhere in the cost department where it is not always easily available.

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"Is it worth repairing?" is a question that should be asked about every piece of equipment, particularly in the case of old or obsolete types, which comes in for repairs. Accurate repair cost data, together with a knowledge of the price of new equipment, will make it easy to give a business-like answer to this question.

How We Get More Light for the Same Money

IN A PAPER presented by J. W. Howell and Henry Schroeder at the recent annual convention of the American Institute of Electrical Engineers some interesting information was presented on improvements in incandescent lamps. The authors point out that if the present 40-watt, tungsten filament lamp were made for the same mean efficiency as Edison's bamboo carbon lamp of 1880, the tungsten filament lamp would have a life of more than 150,000 years. And this does not take into consideration the enormous improvement in larger sizes of tungsten filament lamps due to Dr. Langmuir's invention of the gas-filled lamp. The 40-watt lamp is now over eight times as good as it was when first introduced sixteen years ago.

Improvements in lamps may be utilized either to get more light for the same money or to get the same amount for less money. Users have chosen to get more light and each advance in lamp quality has resulted in increased intensity of lighting everywhere. It is estimated that over half a billion dollars were paid in 1922 for electrical energy used in the United States for lighting. If the present day intensity of lighting were produced by using the bamboo carbon lamp of 1880, the cost of lighting in 1922 would have been increased three and one-half billion dollars. This would have required about fifty billion additional tons of coal, about ten per cent of the total coal production in the United States, to generate energy for the amount of light actually used.

This information on improvements made in lamps during the forty-three years since 1880, when expressed in dollars-and-cents savings to users of light, shows the economic benefit of the engineering work that has made these results possible.

Machines That Supplant Cheap Labor

CHEAP LABOR has been one of the reasons attributed to the slowness of industrial works in the introduction of material-handling equipment. Now that labor costs are so high, many people are advocating the removal of restrictions on immigration so that the supply of labor may be increased. This argument hardly stands up with the facts as recently reported from Europe and Asia, where a big surplus of cheap labor is always available.

For example, one manufacturer of electric industrial trucks reports that European industrial plants are installing electric truck equipment rapidly and one large concern now has over forty in operation. Also, in the January issue of INDUSTRIAL ENGINEER, an illustration showed an installation of portable belt conveyors handling coal at a Japanese power plant. It surely is not because of the inability to get cheap labor that this equipment is installed, since it costs probably at least 50 per cent more there than in the United States.

Investigation vs. A Guess

WORKERS operating under piece-rate or bonus wage payment plans may be counted upon, and rightly, to complain when anything interferes with their earning capacity. In making these complaints they do not always know what is wrong, except that they fall short in their earnings. The tendency, often, is to attribute the trouble to improper time studies and rate settings. In many instances such conditions often evolve into the game known as "passing the buck" which finally ends up in accusations of "incompetence" or "laying down on the job."

At the Automatic Electric Company's plant (see the article beginning on page 432 of this issue), when a group of workers in one of the departments complained of their inability to make bonus earnings, instead of "passing the buck," an investigation was made further than into the correctness of rate setting. The trouble was found to be mechanical and was overcome.

Similar conditions exist in many plants although in a large percentage the blame is passed around until the side least able to defend itself, whether right or wrong or entirely innocent, gives in and accepts the responsibility. Altogether too often entirely innocent parties are discharged because of an arbitrary decision, instead of basing a conclusion on a thorough investigation of the underlying facts. If treated rightly, men seldom "lay down on the job." It pays well, as it did in this case, to investigate before condemning anyone.

What Causes Motor Troubles in Your Plant?

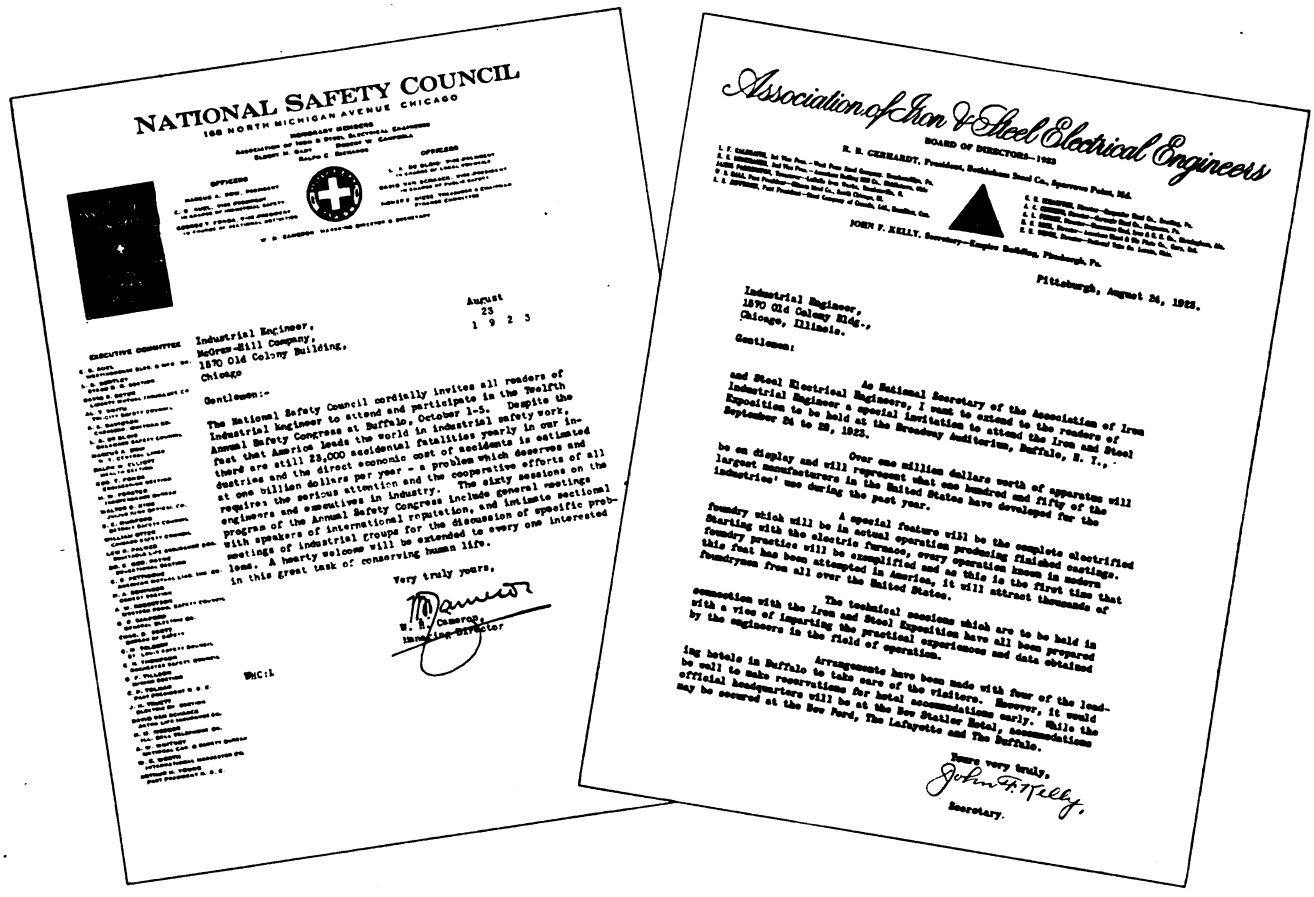
ELECTRICAL apparatus and particularly electric motors are frequently charged with many troubles that originate somewhere else. If motors could talk they would have a lot to say about the abuse they have to stand on account of the mistakes of those who installed them and operate them. Much of this abuse could be eliminated and avoided by inspecting and checking the operation of the mechanisms they drive.

As a matter of fact motors do talk when periodic load tests are made with graphic recording instruments. Some of the things they have to say were shown on page 375 of the August issue in three cases where troubles that showed up in the motor were traced in one case to a bad gear, in another to a faulty brake on a hoist and in another to a faulty pump.

An electric motor as now designed and constructed, is about as sturdy a piece of mechanism as has yet been devised. When properly installed and given periodic inspection, cleaning and lubrication, it will do its work with very little maintenance expense. But when things mechanical go wrong in a machine it drives, it is quicker to show distress signals than most other devices. When these distress signals are attended to like a fire serious troubles are prevented. If they are ignored and the causes not traced to their sources and remedied there, there is charged to the motor a lot of maintenance expense and trouble that rightfully belong somewhere else.

We are attempting to compile data and information that will show how mechanical troubles that show up as motor troubles have been located and corrected. Letters from readers giving their experiences and the results of their studies in this connection will be welcome.

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NATIONAL SAFETY COUNCIL
168 NORTH MICHIGAN AVENUE CHICAGO

August 25 1923

Industrial Engineer,
McGraw-Hill Company,
1870 Old Colony Building,
Chicago

Gentlemen:-

The National Safety Council cordially invites all readers of Industrial Engineer to attend and participate in the Twelfth Annual Safety Congress at Buffalo, October 1-5. Despite the fact that America leads the world in industrial safety work, there are still 23,000 accidental fatalities yearly in our industries and the direct economic cost of accidents is estimated at one billion dollars per year - a problem which deserves and requires the serious attention and the cooperative efforts of all engineers and executives in industry. The sixty sessions on the program of the Annual Safety Congress include general sessions with speakers of international reputation, and intimate sectional meetings of industrial groups for the discussion of specific problems. A hearty welcome will be extended to every one interested in this great task of conserving human life.

Very truly yours,

W. H. Cameron
Managing Director

WHC:k

Association of Iron & Steel Electrical Engineers

BOARD OF DIRECTORS--1923

JOHN F. KELLY, Secretary--Empire Building, Pittsburgh, Pa.

Pittsburgh, August 24, 1923.

Industrial Engineer,
1870 Old Colony Bldg.,
Chicago, Illinois.

Gentlemen:

As National Secretary of the Association of Iron and Steel Electrical Engineers, I want to extend to the readers of Industrial Engineer a special invitation to attend the Iron and Steel Exposition to be held at the Broadway Auditorium, Buffalo, N. Y., September 24 to 28, 1923.

Over one million dollars worth of apparatus will be on display and will represent what one hundred and fifty of the largest manufacturers in the United States have developed for the industries' use during the past year.

A special feature will be the complete electrified foundry which will be in actual operation producing finished castings. Starting with the electric furnace, every operation known in modern foundry practice will be exemplified and as this is the first time that this feat has been attempted in America, it will attract thousands of foundrymen from all over the United States.

The technical sessions which are to be held in connection with the Iron and Steel Exposition have all been prepared with a view of imparting the practical experiences and data obtained by the engineers in the field of operation.

Arrangements have been made with four of the leading hotels in Buffalo to take care of the visitors. However, it would be well to make reservations for hotel accommodations early. While the official headquarters will be at the Buffalo Statler Hotel, accommodations may be secured at the New Ford, The Lafayette and The Buffalo.

Yours very truly,
John F. Kelly
Secretary.

THESE two important conventions will be of interest to industrial men. Those who can arrange their work so as to be in Buffalo during all or at least a part of the two weeks, will find, in addition to the worthwhile papers and talks by experienced industrial men, an exhibition of new equipment and methods which will help them to keep up with the latest advancement and improvement in their fields.

At Buffalo, Sept. 24 to 28 the Association of Iron and Steel Electrical Engineers has arranged for an elaborate exposition. Through the cooperation of the leading manufacturers of equipment over 50,000 sq. ft. of floor space will be devoted to exhibitions of equipment and demonstrations of methods. The most prominent of these will be a complete electric foundry in operation, demonstrating every step in electric foundry practice including standard laboratory practice, with the most modern apparatus, until the metal finally becomes a finished product. In all, over $200,000 worth of foundry equipment will be on display. Some of the practical papers and discussions to be given are listed on this page. Further information may be obtained from John F. Kelly, secretary, at the address on the above letterhead.

During the week following, Oct. 1 to 5, at the Statler Hotel, Buffalo, will be held the Twelfth Annual Safety Congress of the National Safety Council. At this time 60 sessions of special and general interest to industrial men will be held. The nature of the subjects to be discussed is shown by the accompanying program of one afternoon's session.

Association of Iron & Steel Electrical Engineers

A Few of the Papers to Be Presented

Electric Transportation in Steel Mills—F. O. Schnure, Electrical Superintendent, Bethlehem Steel Co., Sparrows Point, Md.

Slip Regulators—D. M. Petty, Electrical Engineer, Bethlehem Steel Co., Bethlehem, Pa.

Systemizing the Work of the Electrical Engineering Division—P. T. Vanderwaart, Electrical Engineer, New Jersey Zinc Co., Palmerton, Pa.

Electrically Operated Centrifugal Pumps—B. A. Cornwell, Electrical Engineer, Carnegie Steel Co., Youngstown, Ohio.

Electric Furnaces—E. T. Moore, Electrical Engineer, Halcomb Steel Co., Syracuse, N. Y.

Electrification of the Iron and Steel Foundry—L. W. Egan, Consulting Engineer, Cleveland, Ohio.

Standardization—F. W. Cramer, Engineer of Tests, Bethlehem Steel Co., Johnstown, Pa.

National Safety Council

One Afternoon's Session

The Essentials of Safeguarding—Dr. A. D. Risteen, Director of Technical Research, The Travelers Insurance Co., Hartford, Conn. (Illustrated with stereopticon slides.)

Compiling and Using Accident Records—R. G. Adair, Safety Supervisor, The American Rolling Mill Co., Middletown, Ohio. (Including exhibition of charts.)

The Bulletin Board—An Indispensable Safety Advertiser—R. T. Solensten, Bulletin Editor National Safety Council, Chicago. (Demonstration with slides.)

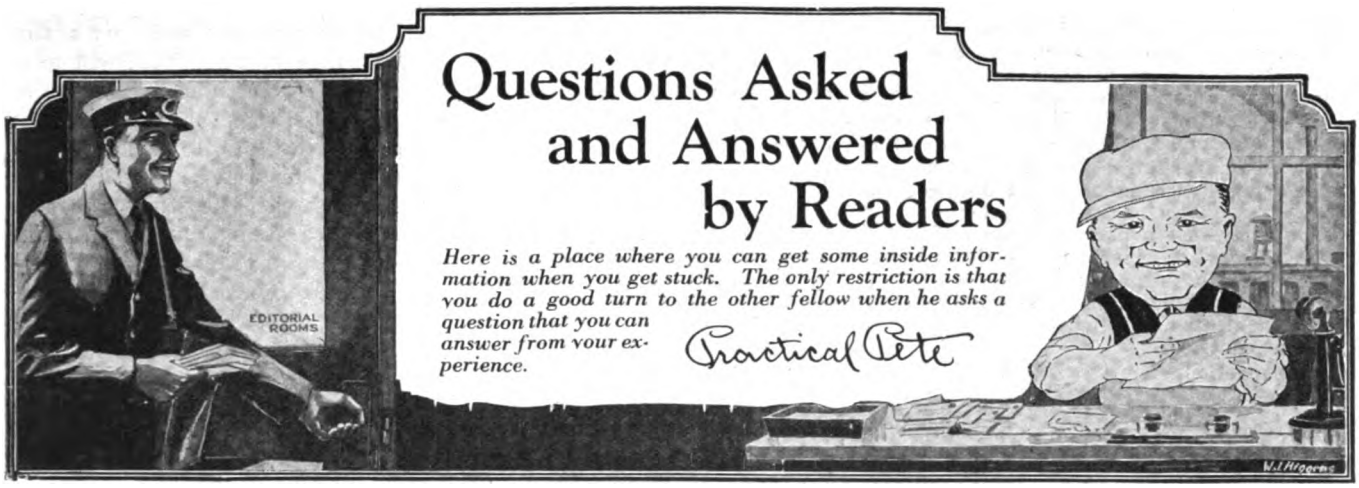
Putting Pep Into a Safety Campaign—Al Kroes, Safety Engineer, Employers Mutual Liability Insurance Co., Wausau, Wis.

Prone Pressure Demonstration—S. H. Reid, Bureau of Safety, Chicago.

An interesting feature of the meetings of the National Safety Council is that the members who come from various industries are divided into groups of men from the same industry. The papers and discussions in each group bear directly upon the conditions and problems and their solution in that particular industry. Several general sessions cover subjects of interest to practically all members and guests, and in addition special sectional meetings devoted to the problems of specific groups cover the activities for the following: Automotive, cement, chemical, construction, education, electric railway, employees benefit associations, engineering, health service, ice and refrigeration, marine, metals, mining, packers and tanners, paper and pulp, petroleum, plant publications, public safety section, public utilities, rubber, steam railroads, taxicab and delivery, textile, and woodworking; in all, twenty-four of the leading industries and their activities.

A special exhibit of safety apparatus is also a feature. Other exhibits show methods and means used in safety campaigns, as for example, a collection of one hundred new safety slides for lecture purposes, and a new film entitled "The Dragon" recently prepared by the National Safety Council. Additional information and a complete program may be obtained from the National Safety Council, 168 North Michigan Avenue, Chicago, Ill.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

How to Figure Power Reactance—Will some reader tell me how many turns of wire to wind on an iron core to give a reactance of about 440 ohms? How large should the core be and how should it be constructed? What formula can be used in this case?
Ada, Okla. F. G.

* * * *

Trouble with Control Equipment of Slip-Ring Motor—I wish some of the readers of INDUSTRIAL ENGINEER would answer the following questions: (1) I have to take care of two 20-hp. slip-ring motors which are controlled by rheostats and magnetic switches. I am now having trouble due to burning of contacts on the rheostats. About half of the segment contacts, counting from the starting position, are affected. The brushes seem to make good contact on the rheostats. This equipment is in use in a stone quarry. Could excessive dust be the cause of this trouble? (2) What is the best equipment to use for testing motors up to 30 hp. for grounds, shorts and so on? (3) I have a 5-amp., 3-cell, vibrator-type battery charger, operating at 110 volts, 60 cycles, which is very noisy. Can this type of charger be silenced to any extent?
Intercourse, Pa. M. A. D.

* * * *

Trouble with Lighting Circuits—I wish some reader of INDUSTRIAL ENGINEER would answer the following question: Recently we were called to look for a ground in one circuit supplying 200-watt lamps. After searching for six hours without finding the trouble, we came upon some outside lamp brackets that were filled with water. There are 1,200 watts on this circuit which is fused for 15 amp., but before we took the water out of the brackets the circuit was fused for 30 amp. and when the fuses blew they would almost strip the fuse holders, so that we could not use the same blocks afterwards. Is it possible that the water had anything to do with this trouble, as we have experienced no difficulty since the water was drained out of the brackets?

I am very thankful to Mr. Todd for the answer which he gave in response to a question regarding a motor which was installed in a school-house and was giving trouble. Since we followed out his instructions this motor has operated very satisfactorily.
Saranac Lake, N. Y. L. J. R.

* * * *

Controlling Group of Polyphase Motors with One Compensator.—I should like to know if any reader of INDUSTRIAL ENGINEER has had experience with starting and stopping a group of polyphase motors, using only one compensator. This method is given in various textbooks, but details and specifications are lacking. We have a group of 440-volt, three-phase, 25-cycle motors ranging from 40 to 75 hp. which are started under no-load conditions, and very infrequently. If one common compensator is employed in conjunction with individual, double-throw, enclosed safety switches, can the latter be equipped with quick make-and-break and made fool proof by having to be thrown first in the starting position? How can no-voltage and overload protection be obtained?
St. Louis, Mo. M. K.

* * * *

Explosion of Totally-Inclosed Motor—I should like to know if any readers have had accidents similar to the following: The stator of a totally-inclosed, split-phase, ½-hp. motor was rewound and after assembly was given an hour's running test. It was then shut down to see how the starting torque compared with a motor of a different manufacture. After a few trials the motor was allowed to come up to speed, but as soon as the click of the starting winding cut-out was heard, it exploded violently, and was broken into a number of pieces.

In this shop black asphaltum paint was used on all windings. At times this paint got thick and was thinned down with benzine. This motor was assembled right after it had been painted, and inasmuch as it was a totally-inclosed motor, heat generated by the winding evaporated the benzine. The starting torque trials made matters worse. Then the motor shaft was released to allow it to come up to speed and as soon as the centrifugal, starting-winding switch operated, a spark was formed on the breaking of the circuit. This spark exploded the gas, wrecking the motor. I have been in this game for twelve years and this is the queerest experience I ever had.
Denver, Colo. A. J. M.

Answers Received To Questions Asked

I have read in the July issue of INDUSTRIAL ENGINEER the answers given to a question asked by J. H. M. in the January issue, in regard to a motor which reverses its direction of rotation.

All of the answers I have read state that the series field is opposing the shunt field, which is satisfactory as a reason for the reversal of the motor when the load is applied, but it does not explain why the motor runs in the opposite direction when it is started up a second time. I think there is something else which J. H. M. either failed to observe or neglected to mention, such as either a partial short in the shunt field or the brushes out of position.

If the shunt field is normal the motor can start only in one direction, unless the brushes are 90 deg. electrically out of position, but in that case it would spark at the brushes.

I advise J. H. M. to check up his observations and make sure the motor does as he says: that is, start sometimes one way, then if stopped, sometimes start the other way. This is impossible unless the machine is heavily loaded with the series field reversed in relation to the shunt field.

There is still something unexplained in regard to this change of rotation when the motor is stopped and started. Give us more data.
Boston, Mass. EDWARD A. GIBBS.

* * * *

Connecting Lights and Small Motors to the Same Panel Board—I would like to get an expression from readers of INDUSTRIAL ENGINEER as to their experience in connecting lights and fractional-horsepower motors to the same panel board. In our plant the incoming feeder is three-wire, three-phase, 110 volts a. c. We have five lighting circuits of approximately

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600 watts and we have six motor circuits with a motor connected to each operating a ventilating fan. The motors are single-phase with the following ratings: two ⅛-hp., three ¼-hp. and one 1/16-hp.

I would like to see a diagram of a panel board arranged with a double bus to connect lights and motors separately, or any other arrangement which may be considered satisfactory. Please also indicate the way these circuits should be fused and the arrangement of switches for individual control.

Seymour, Conn. W. N.

With reference to the question by W. N. in the July issue, if I were doing this job I would buy a standard 30-amp., 125-volt twelve-circuit, three-wire lighting panel and, after removing the panel from the cabinet, I would change the connections of four of the branch circuits so that these would be connected across the two outside busbars, thus making a three-phase distribution panel having four circuits across each phase.

After replacing the panel and mounting the cabinet in the permanent location, bringing the incoming line to the busbars through a 30-amp., three-pole, safety-type, fused knife switch and 25-amp. fuses, I would then connect the motor and lighting circuits to the branch switches, arranging them so as to have the total load balanced across the three phases as nearly as practicable.

I would use 10-amp. fuses for the lighting circuits and for the ¼-hp. motor circuits, 6-amp. fuses for the ⅛-hp. motor circuits and 3-amp. fuses for the 1/16-hp. motor circuit. The unused circuit would be available in case another motor or lighting circuit were needed later.

LEONARD T. JOHNSON.
Electrical Engineer,
W. J. Rainey, Inc.,
Uniontown, Pa.

* * * *

In the July issue, W. N. asks whether or not lights and small motors should be connected to the same panel board and gives the amount of load on each of the circuits in the plant in question.

In his case I believe there is no question that both types of circuits could be fed from the same set of busbars, because the motors in use are so small that the starting and stopping of even the largest of them should not have any noticeable effect on the voltage, and thus cause flickering of the lamps. Moreover, he states that the motors are used to drive ventilating fans, so that they should not take excessive starting current, as the load on the fan will be nothing at the moment of starting and will increase as the fan comes up to speed. This is quite different from cases where the motor has to start with full load.

The rated output of all of the motors together is less than 800 watts while the lighting load totals 3,000 watts. Therefore, the motor load will require only a small proportion of the total amount of current even if the power factor of the motors is not very good and they are not very efficient.

Westfield, N. J. G. H. MCKELWAY

* * * *

Preventing Corrosion of Copper—Will someone please tell me how I can prevent the corrosion of copper parts of equipment that is located in a chemical plant. I have tried everything I can think of, but without success.

Charleston, W. Va. E. B. G.

If E. B. G., whose question on how to prevent the corrosion of copper appeared in the July issue, will thoroughly clean his copper and coat it with clean vaseline, repeating the operation about once a month, he should overcome his trouble, unless the copper gets very hot. In that case he must apply the vaseline more often. This is the method used here under the very worst possible conditions and much of the copper has been in service for close onto ten years. VICTOR ORTH.

Gardenville, N. Y.

* * * *

In reply to the question by E. B. G. in the July issue, I would advise the following: Use ordinary vaseline, smearing it all over the parts to be protected. A thin film is sufficient, although a thick one will do no harm if the temperature of the parts or of the surrounding atmosphere is not high enough to cause the vaseline to run off in the form of oil.

Another method is to tin the parts. This is done in the same manner as tinning a soldering iron or by dipping the parts into molten solder.

These two methods are absolutely reliable, as I have used them successfully under the worst conditions. This same treatment can also be applied to brass or iron parts as well as to copper parts. WM. H. LEWIS.

Jersey City, N. J.

* * * *

The following will answer the question by E. B. G., in the July issue of INDUSTRIAL ENGINEER, on how to prevent corrosion of copper: First thoroughly clean the copper parts with fine sandpaper, remove the dust by wiping and wash with any mild alkaline solution that will neutralize whatever acid may remain. It is essential that the last operation be performed for all acid must be removed; otherwise the desired end will be defeated. Heat the parts to be protected to about 120 deg. F. and apply any high-grade, clear air-drying, armature varnish. This will successfully protect the copper parts.

It is essential, in selecting the varnish, to know that it is chemically neutral and that it has the proper characteristics as regards elasticity to avoid cracks due to the expansion and contraction of the copper.

Chief Electrician, D. L. WAYNE.
Prairie View State Normal College,
Prairie View, Tex.

* * * *

Referring to a question by E. B. G. in the July issue on preventing corrosion of copper, I have found the use of transparent Bakelite lacquer excellent for this purpose. This material can be applied by brushing, dipping or spraying and only a thin coat is required to afford good protection.

When possible the coated object should be placed directly in a baking oven at a temperature of about 300 deg. F. until the coat is hard enough to resist fingernail scratches. This ordinarily requires but a few minutes. In this condition the coating will withstand steam, boiling water and almost all chemicals; for instance, hydrochloric acid, chlorine, cold sulphuric acid and even boiling dilute sulphuric acid will not attack it. It will not withstand boiling concentrated sulphuric acid, nitric acid, caustic soda or caustic potash. However, as these latter chemicals are hardly likely to be brought into sufficiently close contact with the coating to affect it, this lacquer may be used under the most severe, chemical-plant conditions.

Where hardness of the coating is not required the lacquer can be dried at atmospheric temperature. While not so resistant to chemicals in this condition, it will be much more resistant to humidity than are ordinary gum lacquers.

The surface to be coated should be entirely free from grease or oil as their presence will prevent the lacquer from adhering properly. It is to be noted that this lacquer should be thinned only with a special Bakelite lacquer thinner which is furnished by the manufacturer.

When used on parts where electrical contact is desired, such as on

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switch blades and clips, the film would, of course, have to be removed from the contact areas by scraping with a knife or rubbing with sandpaper. The only other way I know of preventing corrosion on exposed parts is to keep them covered at all times with a thin coat of vaseline.

Comerio Falls, Bayamon, Porto Rico. FREDERICK KRUG.

* * * *

Rewinding Motor with Basket-Shape Coils—I shall appreciate it if some reader will give me some information about changing a motor winding. This is a Westinghouse motor, type CCL, 10 hp., 1420 r.p.m., 220 volts, 25 cycles, 3-phase, style No. 137022 A, serial No. 1585893. This motor was rewound with the so-called concentric winding and has eighteen coils of thirty turns of No. 13 wire, two wires in parallel, connected two circuit star. It is very difficult to rewind these motors with a concentric winding wherein the coils are wound full pitch. What changes would be necessary to wind this motor with basket-shape coils, reducing the coil throw and changing the connections?

Joplin, Mo. R. A. F.

In reply to the question by R. A. F. in the July issue relative to a basket winding for a CCL Westinghouse three-phase motor, I have successfully rewound several of these motors, using the same size wire but reducing the number of turns to one-half the former value and using twice the number of coils. The remaining data will be the same as it was before.

In your case, wind thirty-six coils with fifteen turns of No. 13 wire, two wires in parallel. You will have six coils to connect in series for each pole. The pitch and connection will be the same as in a concentrated winding. B. DOWICK.

Jersey City, N. J.

* * * *

Reversal of Rotation of Watt-hour Meter—There are two questions I should like to ask the readers of INDUSTRIAL ENGINEER.

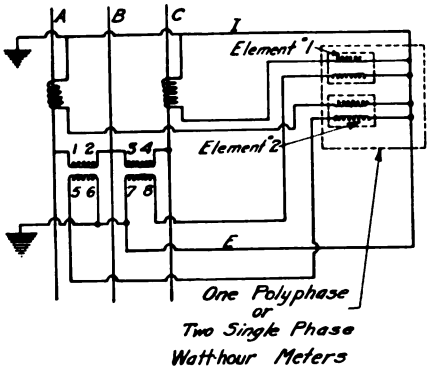
(1) We have an Ingersoll-Rand compressor, driven by a Westinghouse synchronous motor. When this motor is started by an auto-starter the watt-hour meter will run in a forward direction, but as soon as the switch is thrown into the running position, the meter reverses its direction of rotation. By adjusting the field excitation up to 20 amp. the meter will run forward or in the proper direction, but as we have to run this motor with a field excitation of 35 amp. the meter will again reverse and run backward as soon as this current value is reached. This is a polyphase, watt-hour meter and the power factor never goes below 70 per cent. What causes this reversal?

(2) We are about to install four 300-hp., 2,200-volt, 3-phase, 60-cycle motors rated at 69 amp. per motor, or a total of 276 amp. What size polyphase watt-hour meter should be purchased in order to take care of the four motors?

Iron River, Mich. A. J. E.

A question asked by A. J. E. in the June issue regarding the cause of the reversal of rotation of a watt-hour meter was answered completely in the August issue, but I would like to give A. J. E. a satisfactory method of testing the correctness of the meter connections as a further aid in solving his problem.

The illustration shows the conventional diagram of connections for a polyphase meter or two single-phase meters, as the polyphase meters in general use consist of two single-phase elements mounted on one shaft. Leads *I* and *E* are sometimes combined so that the total number of leads to a meter may be only five, although six leads are quite commonly used.



Connections for a polyphase meter or two single-phase meters.

When testing, first make sure that element 1 is connected so that it receives its current from line *C* and voltage from lines *B-C*; also that element 2 receives its current from line *A* and voltage from lines *A-B*. Next, temporarily connect voltage transformer terminal 2 to main lead *C* and note the direction of rotation of the meter disk. The rotation may be in the same direction as with the normal connections or it may be in the reverse direction. If the meter is of the polyphase type it will be necessary to disconnect the voltage connection 8 from element 2.

Then make a similar test on element 1 by temporarily connecting terminal 3 to main lead *A*. If there is no reversal in rotation of either element with these temporary connections, the power factor is either 100 per cent, or is between 50 per cent and 100 per cent, and both elements may be connected so that the disks will revolve in the same direction. If there is a reversal of either element, the power factor is less than 50 per cent and the elements should be so connected that the fast disk will rotate forward and the slow disk in the reverse direction. If the power factor is exactly 50 per cent one of the elements will stand still, that is, it will not rotate at all with one of these connections. It is very difficult in this case to decide how the meter should be connected, particularly if the load varies so as to change the power factor slightly above or below 50 per cent. The only safe procedure to follow would be to have the load held constant until the test has been performed. The writer has found at least one case where the power factor varied from 42 per cent to 58 per cent and the slow element would revolve only a portion of a revolution in either direction. It is usually possible, however, to find a steady load condition which will make the test positive in its results.

C. OTTO VON DANNENBERG.

New York, N. Y.

* * * *

Killing Coils in Stator Winding—I do not quite understand Mr. Roe's main table, on page 138 of the March issue, for grouping the coils in a winding, and should like to have Mr. Roe or some reader answer the following questions: Why does the table show two-parallel, three-parallel, six-parallel, and so on, if there is the same number of groups in three-phase and in two-phase, and regardless of whether the connection is series or two, four, or eight circuit? Also, what does he mean by killing a coil? If he means to leave one coil open so that it is not effective, why? How should I connect a three-phase, four-pole motor having sixty-two coils?

Oakland, Calif. D. M.

In reply to D. M.'s question: When an induction motor stator is connected there should be an equal number of coils per phase. Also, if motor winding is connected two-, three-, four-circuit, and so on, there should be an equal number of coils in each circuit and in each phase. When a number of coils is being used that is not divisible, without a remainder, by the number of phases times the number of circuits, enough coils will have to be cut out to make the answer a whole number. These coils are out of active use and should be cut open.

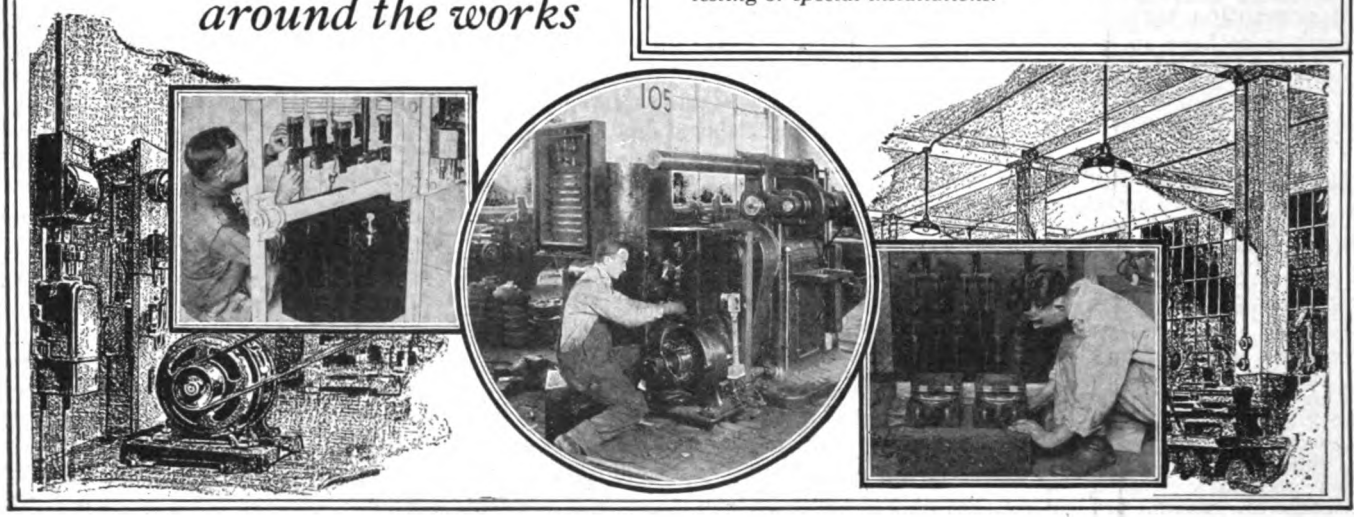
Regarding the method of grouping the sixty-two coils for three-phase, four-poles, two coils will have to be killed, one in phase 1 and the other in phase 2, as explained above.

Detroit, Mich. A. C. ROE.

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SERVICE
around the works

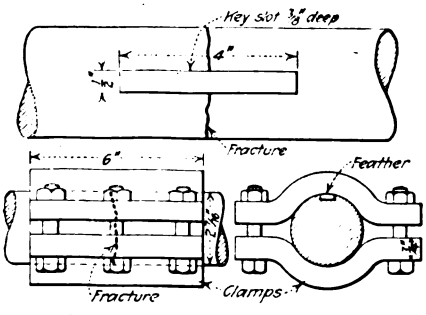
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



How a Driveshaft Was Repaired in an Emergency

A VERY speedy repair was made not long ago to a driving shaft in a St. Louis mill. This was a 2⅞-in. shaft which conveys power to a mill for grinding paint pigments and is driven, through meshed gears, by an electric motor. One day the mill became clogged, causing the driving shaft to break in two. As the mill could not be spared from service, pending the installation of a new shaft, the engineer decided to patch up the broken one.

The broken ends were blocked up until the shaft was in perfect alignment. A keyseat ½ in. wide and 4 in. long was then laid off on the shaft so that the middle of the length of the seat coincided with the fracture. Thus the keyseat would extend a distance of 2 in. along each broken end. The keyseat was chipped to depth of ⅜ in. and a steel feather key was made and driven in, as indicated in the illustration. The projecting portion of the feather was filed down to the contour of the shaft.



The broken ends of the shaft were joined by a feather key and then securely held together with clamps.

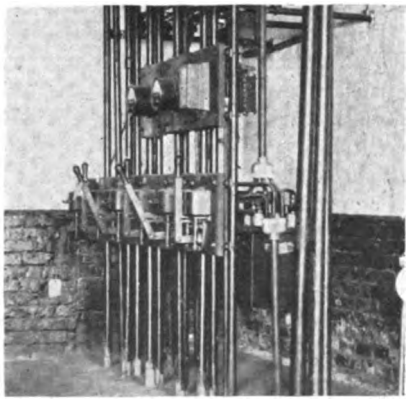
While this work was going on, a pair of clamps, of the form and dimensions shown were being made in a neighboring blacksmith shop. The broken ends of the shaft were then bound together with the clamps, making a continuous shaft which was sufficiently strong for the work. About two hours time was consumed in making the repair.

St. Louis, Mo. A. J. DIXON.

Upright Conduits Used as Frame for Supporting Switches

IN THE accompanying illustration is shown how some upright conduits in a southern cotton textile mill were used as the frame for carrying oil-switch and meter panels. This picture shows part of an auxiliary switchboard in the basement of the plant, underneath the main switchboard. Most of the pipes on which the oil switches and the meter panels are mounted are really conduits carrying conductors to the main switchboard which is on the floor above. The use of these conduits in this way saves the trouble and the expense of putting up a separate frame for carrying this equipment. R. S. HUNTINGTON.

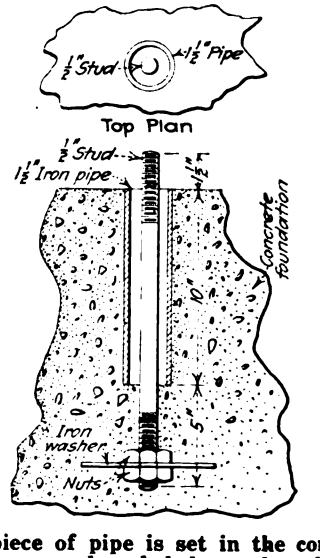
Greenville, S. C.



These switch panels are supported on conduits which run to the floor above.

Simple Method of Making Anchor Bolts Adjustable

ANCHOR bolts set in concrete foundations often do not match up with the holes in the bases of the equipment which they are intended to hold in place. To overcome this difficulty a New York electrical construction company sets a pipe in the concrete around each bolt, as shown in the illustration. This allows the bolt to be bent in any desired direc-



A piece of pipe is set in the concrete around each bolt so that the latter can be bent as may be necessary.

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tion. This particular construction shown here was used in mounting reactance coils. It may be applied, however, to mounting any other equipment in which the bolt holes are in relatively fixed positions.

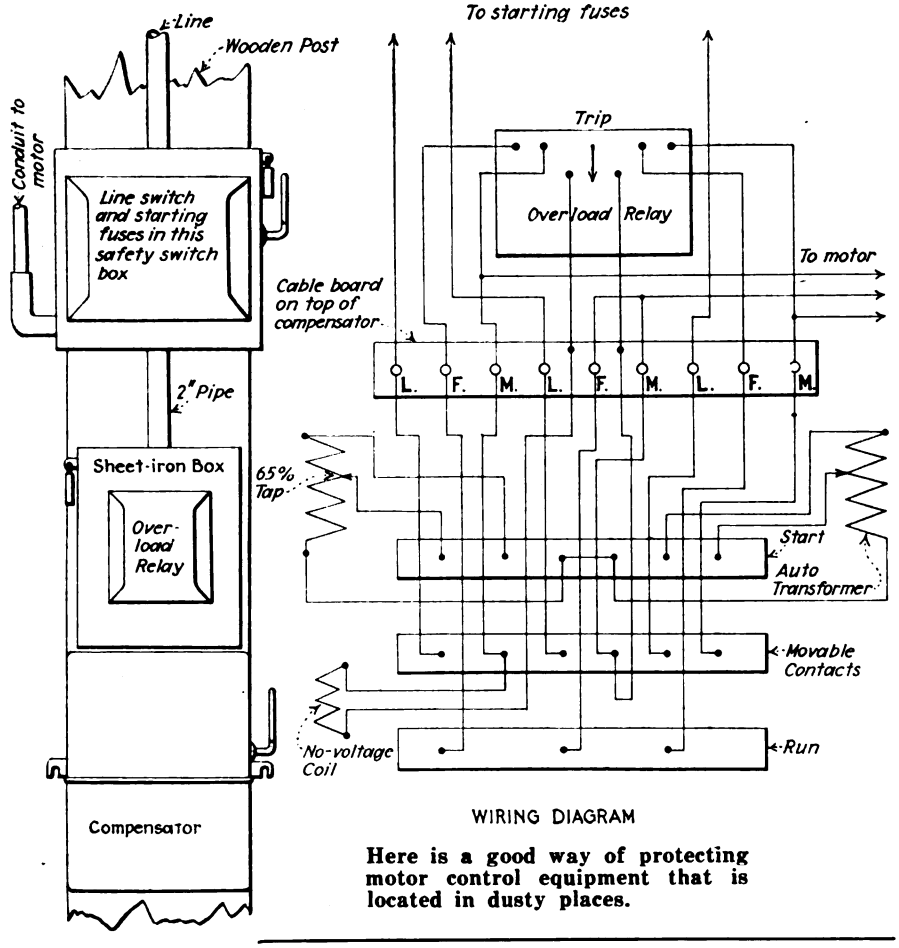
New York, N. Y. FRANK HARAZIM.

Keeping Dust Away From Motor Starting Equipment

WHERE much fine dust and dirt is present in the air it is advisable to protect motor wiring and control equipment from dirt. Such a condition prevails in the factory of the Dominion Oil Cloth & Linoleum Company, where the air is filled with china clay and whiting. To prevent damage to the starting equipment of induction motors, the arrangement shown in the accompanying drawing was developed. This consists of a safety switch, a sheet-iron box, and a compensator, with all connecting wires placed in conduit.

A Square-D fused line switch is used. Through this the motor leads pass. A 2-in. pipe connects this safety switch with a sheet-iron box mounted just above the compensator. This box is 12x20x5 in. in size. In the hinged cover of this box a square hole was cut 1 in. smaller than the slate base on which the overload relay came from the factory. The small feet of this relay were removed and it was bolted directly to the cover. As the relay was back-connected this placed the relay terminals on the inside of the box. In the bottom of this box a hole was cut to fit closely over the cable board on top of the compensator, and all connections were made inside the box. The diagram shows how these connections were made. Locks were put on both the safety switch and the sheet-iron box so that no unauthorized persons can meddle with the fuses, the relay, or the wires. The installation was not very expensive and has proved very satisfactory in keeping the dust away from the starting equipment.

Chief Electrician J. JENSEN.
Dominion Oil Cloth & Linoleum Co.
Montreal, Canada.



WIRING DIAGRAM

Here is a good way of protecting motor control equipment that is located in dusty places.

Leather Cement And How to Apply It When Joining Leather Belts

PREVIOUS ITEMS describing the steps in the preparation of the joint when making leather belts endless appeared in the June, July and August issues of the INDUSTRIAL ENGINEER. These and this fourth item, which describes the two kinds of cement that may be used and their application, are based on the recommendations of The Leather Belting Exchange, an association of leather belt manufacturers.

Regular belting cement is used for making joints in ordinary leather belting. Waterproof belting cement is used for joining waterproof belting or for belts operated under damp or wet conditions. Each is of ample strength and durability and may be obtained from the leather belting manufacturer or dealer.

The regular cement usually comes in cakes or lumps, which are dissolved in water in a double-jacketed glue pot. Any pot with a double jacket, that is, having an inner and an outer vessel, so that the heat reaches the cement through the medium of hot water, and not directly from the flame, will answer, though it is better to use the safety or Underwriter's glue pot, for in it the glue may be maintained under heat directly at the job, and without risk of causing fire. Make the cement hot, but do not permit it to boil. It should be reduced with hot water to a proper consistency to spread easily, and must be applied "piping" hot, to get the best results. It is desirable, too, that it should be applied fresh, and it is better not to attempt to use the remains of a previous melting, if it is old and hard. The pot and the brushes must be kept clean, because the base of this cement is animal glue, which is subject to putrefaction.

Waterproof cement is entirely different in that it is a chemical base dissolved in a solvent other than water. The solvent is very volatile and highly inflammable and it must be kept away from any open light. It reaches the buyer in a liquid form, usually ready to spread, though after some spreading the remainder will grow thicker and should be reduced by the addition of solvent, which can be had from the same source as the cement.

This cement is more like a varnish, and *is used cold.* The surface to be cemented must be thoroughly coated with the cement, well brushed into the fibres of the leather, and then permitted to dry, which, because of the volatility of the solvent, it does rapidly. When dry apply another coat, spreading lightly, and permit this coat to dry in the same manner. When perfectly dry, it is ready for

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the third and last coat. Be sure to apply evenly, and do not leave any bare spots. On belts wider than 12 in. do not attempt to cover more than a 5-in. cross section of the belt at one time, because the solvent evaporates very fast and it is easier to handle a small surface. When applying the last coat, work fast. Do not hammer the joint, but rub it gently, or place it between boards, and apply pressure with bench screws. The joint should "set" for two hours or longer before using the belt.

Waterproof cement substantially is liquid celluloid, and its application places a layer of celluloid between the two surfaces of the lap, in which the leather fibres become embedded. It is unaffected by water, in any period of time, because both its base and its solvent are not soluble, in water. It should be used on all belts that are exposed to damp conditions, or on which water may leak.

Leather itself is waterproof—not in the sense that it does not permit water to penetrate but the leather is waterproof in that though it will absorb water freely, the water does not injure it, and the leather remains substantially unchanged in any amount of water. Leather belts joined with the waterproof cement as described cannot be injured by water. Belts exposed to flood, or to wet conditions, should be kept well dressed with a good animal grease belt dressing to maintain the lubrication of their fibres and to prevent it becoming hard when it dries.

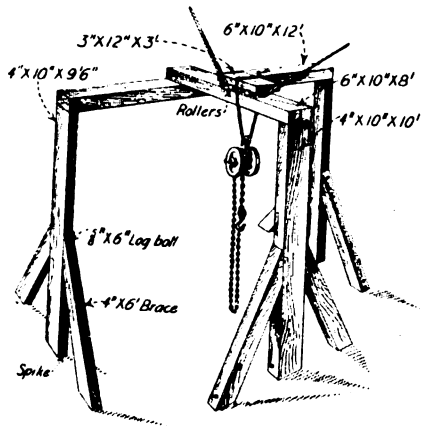
Each of these cements is thoroughly practicable for use on belts without the addition of any rivets, pegs, stitching or other means to hold the plies of the belt together. Thousands of miles of belting are running every day with no other fastening between their plies than one or the other of these cements, and the addition of rivets or stitching not only is unnecessary, but is a positive disadvantage to the belt in that every hole punched for a rivet, or a stitch, is a source of weakness, and reduces the strength of the belt.

The occasion of taking a belt off the pulley for shortening, or for repairs, always presents the opportunity of making a careful examination of it, more particularly to see that it is being properly lubricated. Leather is composed of thousands of little fibres which are constantly working on each other and which require lubrication. Suitable dressings may also be obtained from the manufacturer.

LOUIS W. ARNY.
Secretary,
The Leather Belting Exchange,
Philadelphia, Pa.

Improvised Crane to Take High-Pressure Cylinder From Large Engine

SOMETIME ago it became necessary to remove the high-pressure cylinder from a tandem-compound engine. To do this, we had to slide the cylinder off and away from the high-pressure piston, the amount of movement being about 14 in. when the engine was on the crank center. There was no crane available at that time, and we were therefore forced to make a device to take its place. This was done by setting up a heavy wooden frame as shown in the illustration. This frame was made of three upright posts 10 in. wide by 4 in. thick. These uprights were braced by 4-in. x 6-in. timbers resting on the floor. Two of the upright posts were put on each side of the end of the engine, and across them was placed a 6-in. x 10-in. plank, 12 ft. long. The other upright post was placed against a wall, in a position directly out from the engine. Then a beam 8 ft. long and 6 in. x 10 in. in cross section was laid from the top of this third post to the center of the 12-ft. beam which rested on the first two posts. This 8-ft. beam was directly over, and ran lengthwise of, the cylinder. On this beam was placed a 3-ft. length of 3-in. plank resting on four rollers. These rollers were made of 3-in. pipe and were cut 12 in. long. They were placed under the plank 6 in. apart, the roller nearest the engine being 16 in. from the end of the plank, so that it would not interfere with a pinch bar that was used to move the plank along. This short section of beam was 2 in. wider than the long supporting beam on which it rested, so that when a sling was put around it for holding a chain hoist, the sling would clear the lower beam.



How a heavy cylinder was moved without the use of a crane.

When everything was ready slings were passed around the ends of the high-pressure cylinder and the hoist tightened until it bore the entire weight of the 900-lb. cylinder. The cylinder was then backed off from the piston by having a man pinch the upper or sliding beam along, a very little at a time, while another man stood ready with another pinch bar to limit the movement in order to avoid any possible damage to the piston. The rollers not only lessened the work of sliding the short beam along the support, but made it easier to keep this sliding beam properly aligned. This device worked so successfully that a job which had appeared very difficult at first, in view of our lack of proper equipment for handling it, was done in a short time and without any mishap.

Electrician, HENRY MULFORD.
Patchogue Electric Light Co.,
Patchogue, N. Y.

Light Above Shafting Helps the Oiler and Inspector

IN MANY industrial plants, especially the smaller ones, too little consideration is given to the lighting system. For instance, I have seen many factories where every light was below the shafting, thus making the task of oiling a hazardous one and consequently one to be neglected. Where there is overhead shafting to be oiled, it is often desirable to run a separate circuit above this shafting and arrange it so that the lights may be turned on whenever an inspector or an oiler has to do work upon the shafting.

To my mind there is no part of a plant equipment of more importance than the lighting system. Good light is essential to good work and efficiency and is most necessary from a safety standpoint. Securing good illumination is not so much a question of the number of lamps in a room, as is the location of the lamps. A lamp placed in the center of an open space will light more floor space than a lamp hanging close to a beam or large pipe and on the same level with the beam or pipe. If it is necessary to place a lamp near an obstruction, it should be hung below it

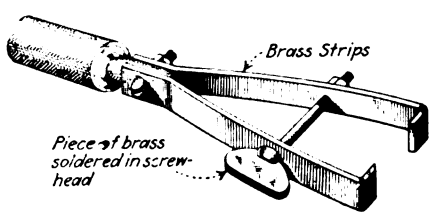
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All wiring, and this includes other wiring besides lighting circuits, should be run in conduits and in a location where there is little chance for damage from broken belts or machine parts or by passing material. H. M. CULLEN.

Turners Falls, Mass.

Easily-Made Clip for Emergency Connections

A SIMPLE clip which can be made from two strips of brass and two small screws is shown in the illustration. Although quick-attaching clips may be purchased, they are not always conveniently obtained. The fastener shown is a serviceable part that can be made up in a few minutes.



This connector can easily be made from brass strips.

For many electrical connections this connector will be effective, particularly on the heavy terminals of a storage battery, and in a switch box for making emergency connections to house wires.

The two brass strips are bent at each end with a pair of pliers to the shape shown. Two holes are drilled through the brass, the one at the end being used for the connection to the wire. The other hole in each of the strips is for a long screw, which pulls the two clamping jaws together and tightens them around a terminal.

The screw used for the clamp should preferably be a thumb screw or should be made so that it can be turned by hand. G. A. LUERS.

Washington, D. C.

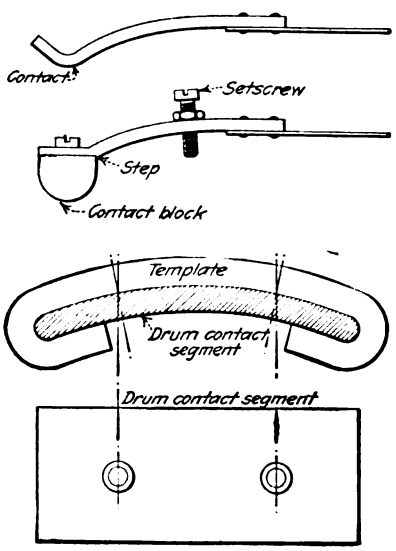
Altering Controller Contracts for Quick Renewal

THERE are now on the market contactor fingers which may be renewed very quickly. However, in the case of some of the older controllers it may save time and trouble to alter the contacts so that they may be readily changed.

For instance the upper drawing in the accompanying illustration shows a typical contact finger fitted to large numbers of controllers. It is obvious that when the contact portion becomes badly burned, the whole finger has to be scrapped. Moreover, during service, the finger either must be filed in position or it must be removed for the purpose. The first method is objectionable in oil-immersed controllers because of the filings getting into the oil and causing short circuits. Further, it is very difficult to file away the burned portion and leave a smooth even surface with the finger in position. Taking out the finger often involves the removal of two small screws which usually are difficult to replace because of the spring in that portion of the finger which supplies the tension when it is screwed home. Both time and money can be saved by fitting the fingers with contact blocks as shown here. Fingers that are not too badly worn can easily be altered and spares may be fitted with blocks ready for inserting in the controller when required. The method of fixing the contact blocks is clearly shown in the figure.

The contact finger to be altered should be heated and the end flattened. Then it should be filed to form a step towards the heel against which the contact block rests when held in position by its screw. This prevents the block turning in the event of the screw becoming loose. The blocks can be cut from square copper bar, which in lengths of say 1 ft. or 1 ft. 6 in. have been shaped in the machine shop. The bars should be marked off, drilled and tapped before being cut into blocks. Afterwards they should be fitted to a standard finger so that they will be interchangeable. The fingers too should be made to a standard, for the same reason. To allow for adjustment each finger should be provided with a set screw and a lock nut, so that as the blocks wear, the fingers may be lowered to keep the contact portion of the block in perfect alignment. The block should be held in position by round-head screws and, if found desirable, they may be fitted with lock nuts. The advantage of these interchangeable blocks is that each controller can be provided with a spare set to replace those taken out for repairs. The block can be changed very quickly, those taken out being filed up in spare time ready for replacing when further repairs are necessary. For controllers which are on heavy service, allowing only short periods when repairs can be made, these block contacts are very convenient.

If necessary drum contacts can be made in the shop. With a pair of calipers the diameter of the controller drum, with the drum contacts removed, should be taken. This will be the inside diameter of a copper tube of suitable thickness, which, when cut up will provide drum contacts with the same curvature as those already in use. The copper tube may be purchased in lengths of a few feet, being placed in a lathe and cut into rings of the required width. These are cut as required.



Contact fingers and plates prepared for quick renewals.

The drum contacts should have their holes accurately drilled, and they should be interchangeable. Therefore it is best to make them in a template, as shown. This can be made out of ¼-in. or ⅜-in. iron. It should be shaped and drilled to a new drum contact which is kept as standard. The template and drum contact should be of the same width so that when the latter is inserted and wholly covered by the template the holes will be drilled in the centre of the contact.

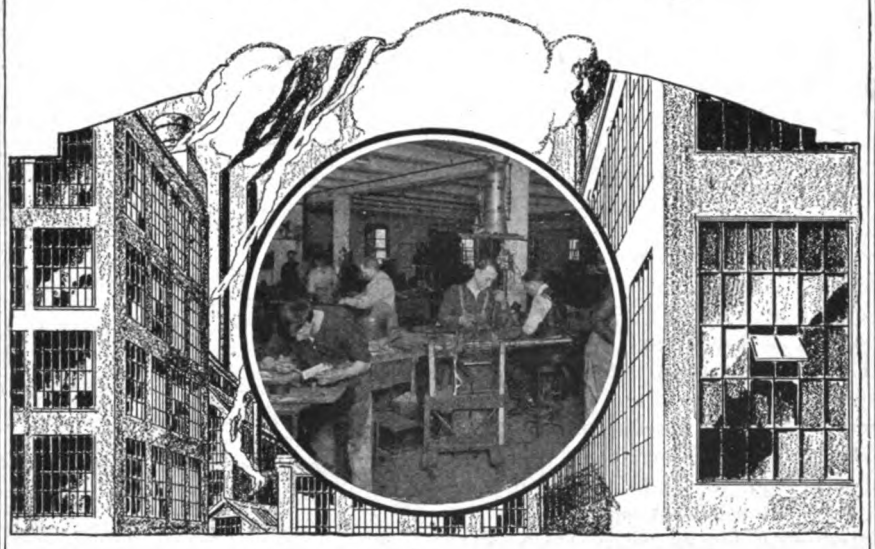
Drum contacts of course burn on only one end; therefore they should always be reversed in order to get the maximum service out of them. A spare set of these should be kept so that no filing is done in the controller.

When filing a drum contact the end should be properly rounded. This ensures a quick connection when the moving contact encounters the fingers. If they are filed at an angle, as is sometimes wrongly done, contact is established and broken much more slowly and burning is more severe. R. FOKES.

Walton-on-Thames, Surrey, England

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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Model to Show Revolving Field of Induction Motor

THE ACCOMPANYING drawing shows a model which I devised to help myself in getting a conception of the revolving field within a two-phase induction motor. This particular model is for an eight-pole, 900 r.p.m., 60-cycle, 220-volt two-phase motor.

In an induction motor the stator iron is uniformly distributed and slotted, and the winding is uniformly placed in the slots. This construction makes possible the production of a uniform revolving field since the air gap as well as the reluctance of the magnetic circuits is uniform. The toothed circle in the model represents this construction. For the sake of clearness, however, the coils are shown concentrated around physical poles. There are sixteen of these poles, eight for each phase, to give the eight revolving poles. The effect of the coils is considered to be the same as if they were uniformly placed in the slots as in an actual motor. The letters A^1, A^2, B^1, B^2 around the outside of the physical poles of the model show the phases to which the poles belong. It is not practicable to mark them respectively *N* and *S* because their polarities are constantly alternating.

These poles are connected up as they would be in a stator and are connected to the two-phase system shown above. In the drawing of this system the solid arrows on the leads represent the positive direction of the currents, and the dotted arrows the negative.

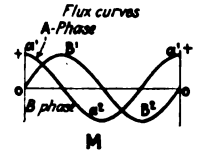
At *M* are shown the usual sine curves of a two-phase system. In this case they represent the magnetic flux set up in a pole (or pole-phase group). In making the model these curves are transferred to the circular form as shown at *P*. In this drawing the zero line is the circular line shown by *0-0-0-0*. Values outside of this circle are positive while values inside are negative. The curve for the *A* phase is maximum positive under the poles marked A^1. It is zero under both B^1 and B^2. Under A^2 it is maximum in a negative direction. The curve for the *B* phase is drawn in the same manner. The innermost circle represents the rotor with the rotor bars shown as dots.

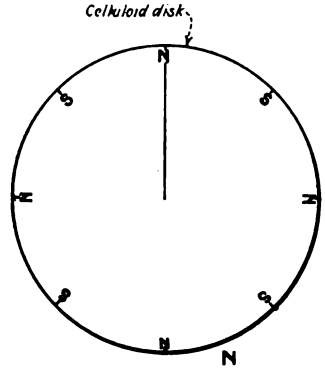
A circular disk of clear celluloid is cut out, of the relative size shown at *N*. Eight poles are marked near the circumference of this disk as shown by the letters *N*, *S*, *N*, *S*, and so on. One north pole is connected to the center of the disk by means of a straight line. This is used as a reference line.

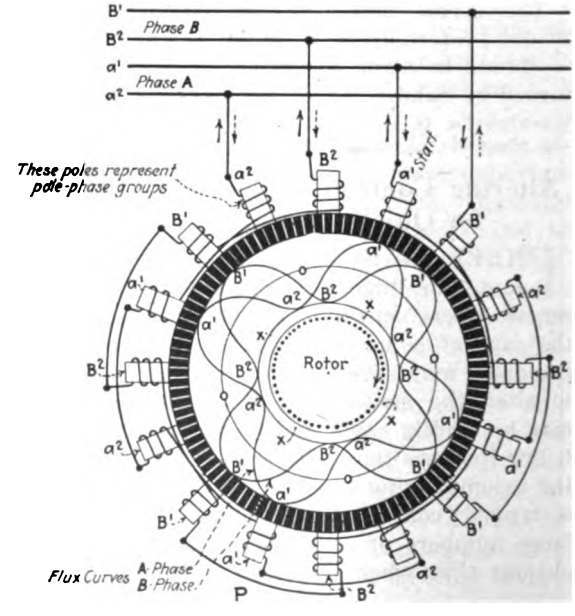
Now to use the diagram the disk is placed over it with the centers coinciding. A pin is stuck through the centers so that the disk can be revolved. Revolving the disk to the right we see the effect of the revolution of the magnetic field set up by the current in the windings. The most valuable purpose of the model is to show how this field is composed from the alternating fluxes of the two phases. This is seen by watching the flux lines underneath the radial reference line on the disk. As the reference line moves around, the *A*-phase flux grows from zero to maximum and then goes back to zero and to the negative maximum. The *B*-phase flux does likewise but always after the *A*-phase flux.

Stopping the disk at any point we see that the north and south poles are located in certain positions. At

This model explains simply the revolving field of an induction motor. The diagram at *P* can be used as it appears here without copying. The disk at *M* is made of clear celluloid of the exact size shown. The disk is placed over the diagram and a pin is used as a pivot.







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any instant the north pole is formed by the sum of the flux from the *A*-phase and the flux from the *B*-phase. The value of the flux due to the *A*-phase is indicated by the point where the reference line on the disk cuts the *A*-phase flux curve as explained before. Likewise the value of the flux due to the *B*-phase is indicated by the point where the reference line cuts the *B*-phase flux curve.

It must be remembered that the flux caused by the *A*-phase does not move around the stator. It only varies in intensity while remaining stationary under the *A*-pole. Likewise the *B* flux varies but always in one place. The combination of the two, however, results in magnetic poles which move around the stator. These magnetic poles are maximum first under an *A* pole and then under a *B* pole, and so on.

The dots on the rotor appear to recede as the disk and its radial line move over them. This illustrates the cutting of the conductors by the revolving fluxes when the rotor is standing still. In an actual motor the rotor will begin to turn in the direction in which the disk is now turned. It will never turn quite as fast as the magnetic field revolves.

The action of a three-phase motor might be illustrated by a suitable model in the same way as a two-phase motor. The model, however, would be more difficult to make and also to understand.

Chief Electrician, HENRY MULFORD.
Patchogue Electric Light Company,
Patchogue, N. Y.

Motor Record Card Gives Complete Information About a Motor

THE ACCOMPANYING illustrations show the front and back of a motor record card which we use for all of our motors and which has been found to be very convenient.

Here is a record card that gives practically any information desired about a motor.

Form 51-6 5-'22-5C

ELECTRIC MOTOR DATA CARD

Shop No. 8080 Line No. 8 Dept. No. 4 Purch.

Mfr. Crocker Wheeler Co.

Type A. C. Ind. D. C. Series Open ✓

Sync. Shunt ✓ Enclosed

Ph. Comp. Semi-encl.

Cycle

Rating — H. P. 75 Frame No. 207 Code—39430

Amp. 268 ~~Style No.~~ Size 75 D

Volt 230 ~~Field Serial No.~~ Type CM

R.P.M. 530 Arm. ~~Serial~~ No. 1225

Shaft Diam. 3½ Keyway 1 x ⅜ Pulley Dia. 20" Face 18½"

Free Length 6-4"

Controller— W. E. M. CO ◯ Brushes 2½ x 2½ x ⅜ (16)

ARMATURE DATA

Type of Winding—Wave Lap. ✓

Size Wire 12 DCC

No. of Wires per Turn 6 in multiple

No. of Turns 2

No. of Slots 60

No. of Commutator Bars 120 Bar 1-is opposite left side of coil

Throw of Coil—14½ R ✓ L—in slot 1-15-16. 2 coils per Group

Throw of Lead—Start 29 Finish. 30

Coil Insulation— ½ lap .070 linen tape

Slot Insulation— { 2-.010" fish paper / 1-.010" oiled mus- ◯ lin

Band Wire—№16 - 6-½" on core ◯ 1½" end band

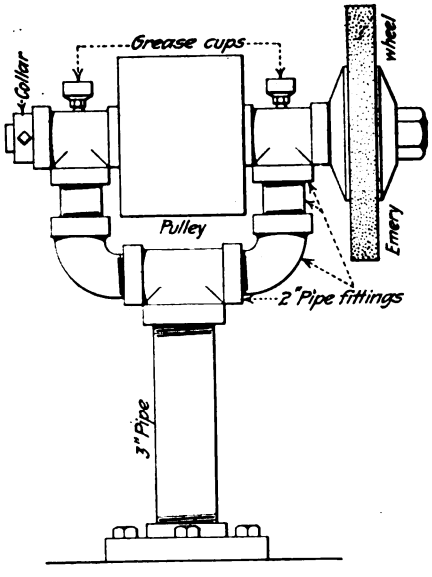
As will be seen, the front of the card, upper half of illustration, gives the data as to make, size, location and so on usually kept on a motor record card and in addition gives the diameter and face of the pulley, shaft diameter, size of keyway and size of brushes. On the reverse side of the card there is given complete winding data, including size of wire, number of turns, number of slots and bars, throw of coils and leads, kind and size of insulation, and so forth. In case trouble develops or any questions come up regarding a motor, a glance at the card will give practically any information that is desired. On more than one occasion these motor record cards have saved us time and trouble when definite information was needed at once.

Chief Electrician, E. J. FORD.
Walworth Mfg. Co.,
Kewanee, Ill.

Reclaiming a Seemingly Wornout Emery-Wheel Arbor

WHILE looking through a scrap pile containing discarded odds and ends of machine parts and fittings, an operating engineer found an old emery-wheel arbor which appeared to be still serviceable except for a little scoring of the journals.

First he centered the arbor in a lathe and trued up the journals. Next he made a stand for it out of pipe fittings. The fittings consisted of two 2-in. tees for the bearings, two 2-in. ells, a heavy floor plate and short piece of 3-in. pipe for the standard, a 2-in. x 2-in. x 3-in. tee to receive the standard, and two 2-in. nipples.



Pipe fittings were used to make a new stand for the old emery wheel arbor.

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A ½-in. pouring hole and two ¼-in. vent holes were drilled in the top of each bearing tee. The arbor was then set horizontally in the tees and one of the journals was babbitted. After the arbor had been removed and the babbit-metal bearing had been filed out to an easy running fit, it was again set in place and the other journal was babbitted and its bearing likewise filed out.

St. Louis, Mo. A. J. DIXON.

How to Build an Electric Furnace for Heating Soldering Irons

ALTHOUGH it is advisable in most cases to buy a soldering-iron furnace instead of making one, there may be occasions where it is necessary to build one. Those who find themselves in such an emergency may be interested in the soldering iron furnace which was built by the writer. It can be constructed at a comparatively low cost; the table shows the material required for one furnace. It takes 14 amp. at 110 volts and will heat 2-lb. to 5-lb. irons. By eliminating the open flame of the gasoline torch it reduces the fire hazard. It also gives an even, clean heat all over the iron, and its maintenance cost is very low in comparison with gasoline torches which will do the same work. Twenty of these have been built for work around our factory.

This furnace consists of a sheet-iron box with a handle and feet, as shown in the accompanying illustration. The heating element consists of a muffle on which is wound one-half pound of No. 14 gage Nichrome wire. Connections are made with the outside by means of an electric receptacle connected to both ends of this Nichrome wire.

After the sheet-iron case is put together all joints are spot-welded and the same process is used for fastening on the legs and the handle. Then all cracks are sealed with asbestos cement. Next, the bottom is covered with Nonpareil bricks to the correct height for supporting the element, as shown in the diagram. A coat of asbestos cement is put on top of the bricks and the heating element and connection plug are laid in position. The entire inside space is then filled with Nonpareil bricks, all cracks and holes being filled with asbestos cement. Then the front cover, which is made of ½-in. compressed asbestos, is put in and fastened in place by means of screws passing through the sheet-iron box. In this front cover a hole was previously cut just the size of the inside dimensions of the muffle so that the irons may be inserted. A small sheet-iron shelf also is fastened on the front cover below the entrance.

After the oven is assembled it is finished with two coats of bright aluminum paint. A. S. BARKER.

Power Foreman,
Naval Aircraft Factory,
Philadelphia Navy Yard.

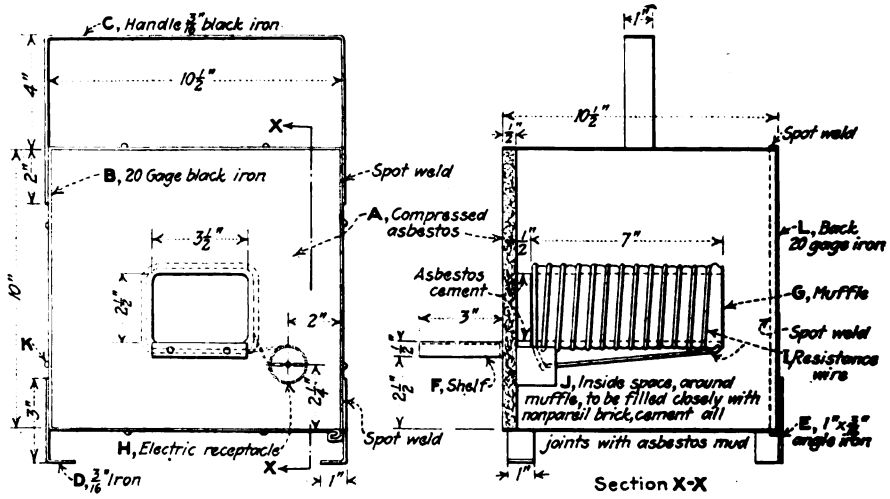
How to Lengthen Life of Motor Exposed to Weather

THE writer was very much interested in the article by Mr. Smith of Swift & Company, in the November issue of INDUSTRIAL ENGINEER, in which he told how he increased the life of motors which had normally held up only about nine months. We had a worse case than that. One of our customers had a motor that burned out every three months, on an average, because of exposure to the weather. We rewound it sixteen months ago and it is still going.

We made up the coils with double-cotton-covered wire, pulled them to shape and dipped them twice in liquid bakelite, baking for 12 hours at 212 deg. F. after each dip. Then we put on one layer of half-lapped 0.007-in. cotton tape and dipped the coils again in bakelite. No paper cell was used in the slot section to hold the coil rigid. Copper clips were used and these were removed after the first dip, the bakelite holding the coil.

After the layer of cotton tape a 1½-turn mica and fishpaper cell was put on. The cell was painted with bakelite before putting on. The ends were taped with 0.009-in. black bias-cut treated-cloth tape ¾-in. wide. This was also painted with bakelite while applying. The coils were then taped with 0.004-in. cotton tape half-lapped and baked for 32 hours at 212 deg. F. and then dipped while hot in bakelite. After the coils were in place the whole motor was dipped in bakelite and then baked for 18 hours at 212 deg. F. This motor should give good service for at least four years. A. C. ROE.

Detroit, Mich.



Construction details of electric furnace for heating soldering irons.

Material Required for Building One Soldering-Iron Furnace

Letter	Part	Material	Size of Material	Amount Required
A	Front	Compressed Asbestos	10½ in. x 10 in. x ½ in.	1
B	Cover	Black iron	No. 20 gage, 10½ in. x 42 in.	1
C	Handle	Black iron	22½ in. x 1 in. x 3/16 in.	1
D	Feet	Black iron	2 in. x 3 in. x 3/16 in.	2
E	Feet	Angle iron	1 in. x 4 in. x 3/16 in.	2
F	Shelf	Black iron	No. 20 gage, 4⅛ in. x 4½ in.	1
G	Muffle	Hoskins "Improved"	4¼ in. x 3¼ in. x 7 in.	1
H	Receptacle	Hubbel, female	1 1/16 in.	1
I	Wire	Nichrome	No. 14 gage	½ lb.
J	Bricks	Nonpareil	To fill space	
K	Screws	Iron	½ in.	8
L	Back	Black iron	No. 20 gage, 11 in. x 10½ in.	1

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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

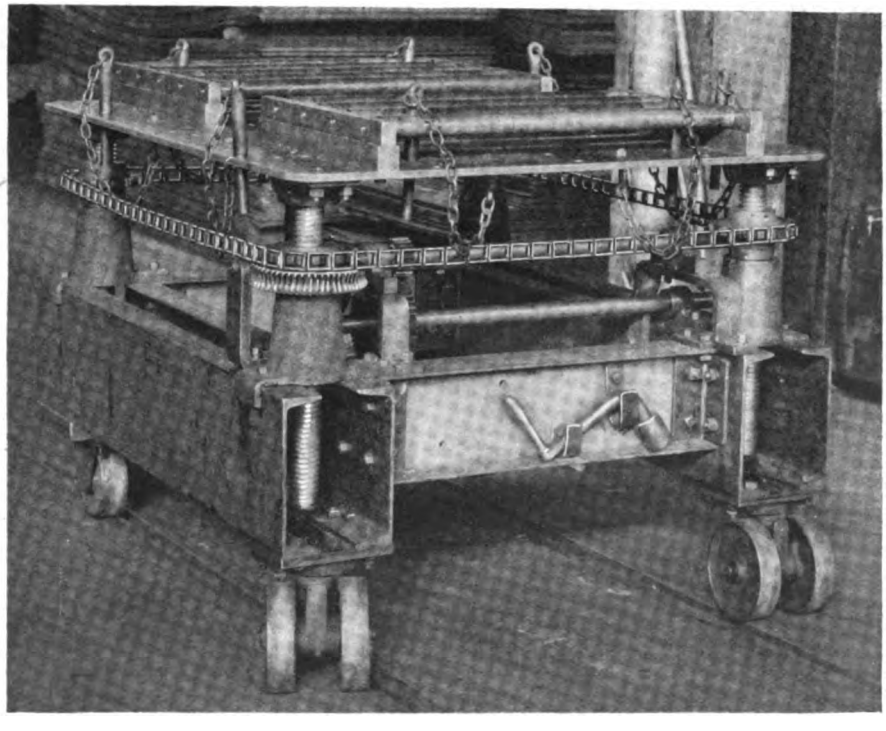
How a Special Truck Increases Production by Saving 60 Per Cent in the Time and Labor Cost and Also Eliminates Accidents

MATERIAL HANDLING equipment, if well designed, usually does more than merely reduce the cost and time of performing handling operations. Such at least was found to be the case at the Detroit plant of the Michigan Stamping Company, where a special truck, as shown in the accompanying illustration, was designed to facilitate the changing of dies. In changing these heavy dies, speed is an important factor because while idle the press is losing production. However, speed frequently results in accidents but in this case when the truck was installed accidents were eliminated as well as the time of changing the dies shortened.

Frequently stamping plants are equipped with power cranes to carry the die directly to a flat-top table placed in front of the press and from this the die is easily and safely slid onto the bolster bed. In other cases, monorail hoists or chain-falls are used for the same purpose. Where the dies are not too heavy and in plants where the shop is so arranged that it is not necessary to re-handle the die between storage and the press, this method is very satisfactory. The main difficulty lies, however, in the fact that these tables are seldom of just the right height, and so it is usually necessary to block up the die and place rollers beneath it so that it can be skidded into place. This not only requires time but is hazardous.

At the Michigan Stamping Company, which is operating several hundred presses on auto body work, many of these dies, as for example, a new model of many cars requires about 300 dies, some of which weigh several tons, must be handled to and from the presses. After trying out a number of plans this company built the portable truck or table shown. In using this truck the die is taken from the storage and lowered onto the roller top by a traveling crane. The top is so constructed that the sling chain drops into the space between the two sections of the top and when loosened the chain can be quickly drawn from under the die. In cases where the stamping press can be reached by the traveling crane, this truck is placed directly in front of the press and the die carried to it by the crane. In other cases the die is loaded on the table in the storage room. The table then serves as a truck to carry the die sometimes as much as 500 ft. Usually in long hauls this table truck is lifted and carried by an electric lift truck, although it is on casters so it may be pushed or turned by hand.

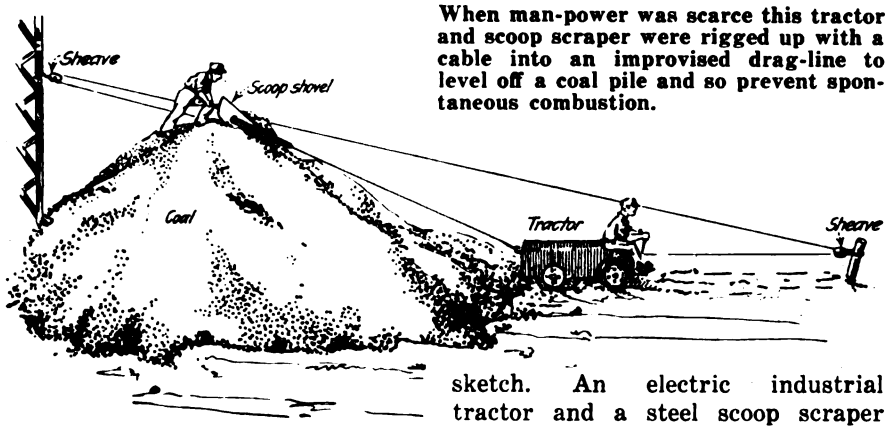
In case the table top is not of the proper height to fit the press, the crank shown on the front is attached to the end of a cross shaft which through worm gears raises or lowers simultaneously the four jacks at the corners to the proper height to bring the dies to the level required. This



A special truck for handling stamping dies at the Michigan Stamping Company.

This truck is on special casters so that it may be pushed by hand and is also so constructed that it may be handled on an electric lift truck. The special roller top has a vertical travel of 11 inches so that it will fit practically any press. This has resulted in a reduction of 60 per cent in the time and labor cost of changing dies with a corresponding opportunity to increase production. In addition no accidents have occurred to the die setters during the year in which it has been in use.

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When man-power was scarce this tractor and scoop scraper were rigged up with a cable into an improvised drag-line to level off a coal pile and so prevent spontaneous combustion.

table top is 32 in. by 40 in., and has 11 in. vertical travel, from 31 in. minimum height to a maximum height of 42 in., which will fit practically any press. When the table top is level with the platform the die can be easily rolled into position without danger of accident to the die setters. Peg pins, attached to the frame by chains so that they cannot get lost, are placed around the die to prevent it shifting position.

Another big advantage of this truck is that the table is not top heavy and will not tip over, which, because of the weight, eliminates a dangerous accident hazard. In addition to saving about 60 per cent in the time and labor required to set or remove a die, an additional reduction of accidents has resulted. For example, during a fourteen-month period before this table was installed three fingers had been lost at this work in addition to seven time-losing accidents. Since this truck was installed no accidents whatever have occurred to the die setters. This alone is worth the cost of the truck.

Improvised Drag Line Made From Scraper and Tractor for Leveling Coal Pile

IN ONE industrial plant, coal was unloaded by a cable coal conveyor and dumped in piles in the factory yards. When the pile became too high and peaked it was necessary to level it off, both to increase the storage capacity and to prevent spontaneous combustion due to too great a depth. As man-power was scarce, and also very slow and expensive, it was decided to install power-driven equipment to spread the coal. To do this, a $\frac{5}{8}$-in. steel cable was rigged up so that on one side of the pile it passed through a pulley block attached to an iron column and on the other side to a stake, as shown in the accompanying sketch. An electric industrial tractor and a steel scoop scraper were attached to the cable as shown.

The cable was fastened to the front and to the rear of the tractor which traveled back and forth on a concrete roadway adjoining the coal pile. A man on the top of the pile filled the scoop, which was pulled by the tractor, on its forward trip, and dumped it at the edge of the pile. As the tractor backed up it pulled the scoop up to the top of the pile again. By not making the cable too tight, a considerable area was covered without resetting. H. S. RICH.

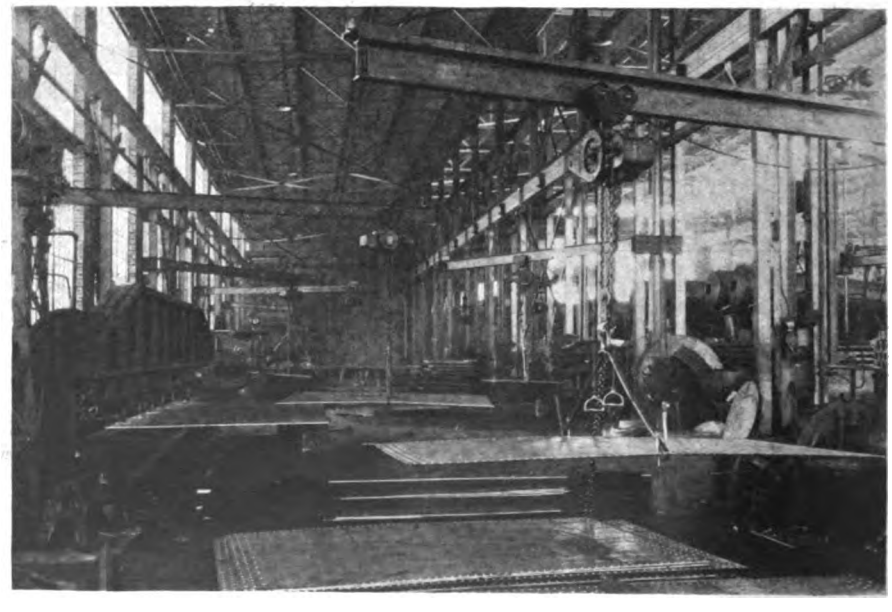
Little River, Conn.

Lifting and Holding Heavy Work by Electric Hoists While Fabricating

WHERE heavy work must be lifted and held in position while it is fed to punches, shears and similar machines electric hoists have won a place as a time-saver and aid in the increase of production. Hand hoists could, of course, be used but their operation would slow up the work and result in a corresponding increase in the time required for setting-up and preparation of the work. For example, at the Union Iron Works, Erie, Pa., seven Yale Model 20 electric hoists (Yale & Towne Mfg. Company, Stamford, Conn.) are used for lifting the work to the machines and holding it while in process. Six of these hoists are in use on swinging I-beam jib cranes handling iron plates to the rolls, shears and punching machines. Of primary importance in this work is the accuracy of the lead hook; that is, the hoist must be so accurately balanced that the work is practically level and the hoist can thus hold the steel in the right position when punched or sheared. The ease with which this feature is obtained is well illustrated by the accompanying photograph. Here the plates are gripped with a special set of tongs for handling plates.

The hoist over the bull riveter is probably the most interesting part of the installation as this was installed in place of a more expensive electric riveting outfit.

The riveting machine is stationary on the floor and the assembling work is spotted in the machine for riveting. This requires frequent movement of probably two or three inches between operations. These movements are easily made on account of the hoist and the special carrier on the I-beam. This is simply another instance where power-driven equipment has replaced hand-operated devices with a saving in time which has had its effect on production.



Part of an electric hoist installation at the Union Iron Works.

An installation of seven electric hoists handles the steel plates and structural work to and from the shears, punches, riveting machines and other apparatus at this plant.

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Checking up Winding Diagrams

(Continued from page 446.)

After this the lines inside of these heavy lines are taken away as at *D*, and we have the simple single-line diagram. The direction of flow of current on the single lines will be the same as that indicated by the arrows on the stubs between the coils. After these lines are drawn each one of the leads coming from the group is given a number or a letter. The first lead which connects to the *A* line is called *A;* the outgoing lead of group 1 is called 1. This connects to the top lead of group *B* and this lead is also called 1. Then the bottom lead of group 3 is called 3. This connects with the bottom lead of group 5 and this bottom lead is also called 3. Thus by lettering the leads in this manner we can tell which leads connect to which. All leads which have the same number are connected together by jumpers.

Each of the heavy lines in this drawing represents one group of coils. It may be used to indicate any number of coils and the coil pitch may be whatever is desired. The number of coils per group and the coil pitch can be noted on a winding card. Where some groups have more coils than others, this also may be noted on the card.

How Single-Line Diagrams Are Drawn for Any Winding

There are a number of points that should be understood in connection with constructing and checking single-line diagrams. Fig. 7 shows the steps in constructing a two-phase four-pole series diagram when using the top-to-top or short jumper. The first step is shown at *M*. This shows a circle divided into eight parts as there are eight pole-phase groups in the machine. After this is done then call any group No. 1 and number the rest consecutively clockwise as shown by the figures in the small circles. Then start at group 1 and put direction arrows on the groups. In a two-phase machine there will always be two adjacent groups having the same direction. The next two groups will have arrows in the opposite direction. As seen, groups 1 and 2 have arrows pointing to the right, while groups 3 and 4 have arrows pointing to the left. This is repeated throughout the circle. After this is done one end of group 1 is taken as the *A* lead. A letter *A* is put at this end of the group as shown. For convenience the left-hand side of each group is called the top lead and the right-hand side is called the bottom. Taking the top leads for the line leads, place the letter *A* at the left or top of group 1. Then the bottom lead of this group is connected by means of a jumper to the bottom lead of group 3, skipping one group. For convenience in drawing the jumpers several light circles may be drawn in outside of the main circle. Then the jumpers are drawn to follow these circles. The first jumper leading from group 1 is called No. 1 jumper and the bottom end of group 1 is marked with a figure 1. The other end of this jumper, which goes into the bottom of group 3, is also marked with figure 1 as shown in *M*. Then as at *P*, connect the top of group 3 with the top of group 5, again skipping one group. This jumper is called 3, and the figure 3 is put at the top end of the line representing group 3, and also at the top end of the line representing group 5.

At *Q* this process is carried one step further. A jumper is connected from the bottom end of group 5 to the bottom end of group 7. This jumper is called 5 and the figure 5 is placed at the bottom end of the lines representing groups 5 and 7. There are now four groups in series, which completes the *A*-phase.

At *R* the *B*-phase is started. The bottom side of group 2 is connected with the bottom of group 4 by means of jumper 2. This is continued at *S* by connecting the top of group 4 to the top of group 6, and this is carried forward further in *T* by connecting the bottom of group 6 to the bottom of group 8. This completes the *B*-phase. The line leads are then put in as shown at *T*.

To check this winding start at the *A* lead and follow through the groups that are two groups apart. These groups should be connected in such a manner that the arrows on alternate groups in the same phase reverse. The *B*-phase is then checked in the same way.

The diagrams just described have shown the short jumper or the top-to-top jumper. At *U* of Fig. 7, is shown the same winding connected up with the long jumper or the top-to-bottom jumper. In the latter winding all the north poles are first connected in series by means of long jumpers. Then from the end of this series of north-pole groups a short jumper connects to the series of south-pole groups. At *U* of Fig. 7 one phase of the top-to-bottom connection is shown.

To draw this kind of diagram connect *A* lead to the top of group 1. Then the bottom of group 1 is connected to the top of group 5, skipping over three groups. This is a general rule for a long jumper on a two-phase machine, that is, to skip over three groups. As this is a four-pole machine there are two north poles and two south poles. Consequently as two north poles have now been covered, we must pass to the south poles. Therefore the bottom of group 5 is next connected to the bottom of group 6, thus connecting the series of two north poles to the beginning of the series of two south poles. This is a short jumper and in this case is reversing, that is, it passes back in the opposite direction to the direction in which the first long jumpers pass around the winding. Then the top of group 3 is connected to the bottom of group 7. The top lead of group 7 then forms the outgoing line lead, A_1.

This short jumper from group 5 could have connected to the bottom of group 7 if it had been desired. In this case the jumper would have been called "leading" instead of "reversing." With the leading jumper the top of group 7 would be connected to the bottom of group 3 and the top of group 3 would be the outgoing A_1 line lead.

Comparing Advantages of Short and Long Jumpers

The short jumpers have certain advantages while the long jumpers have others. With the short jumpers (top-to-top connection) the coil leads themselves can be left long enough to serve as jumpers and thus eliminate the use of additional wire and a number of soldered joints. The short jumper makes a neater job as there are fewer cross-overs than with the long jumper. When unequal grouping is used the large groups can often be spaced more symmetrically if the short jumper is used.

The great advantage of the long jumper with parallel connections, is that it will compensate for unbalanced magnetic pull due to wear of bearings and other causes. One objection is the large number of cross-overs but this can be overcome by allowing the jumpers to stand up. With large machines this type of

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jumper is too long and cumbersome.

In all of the two-phase diagrams shown so far the top leads have been used for line leads. However, it is immaterial whether the line leads are attached to the top leads of the groups or to the bottom leads provided the groups are connected in proper sequence and polarity. In Fig. 8 is another method of drawing the groups of two-phase windings. Drawings *A* and *B* in Fig. 8 illustrate the difference between using top leads and using bottom leads, for the line connections. Both of these drawings show a four-pole two-phase series connection. In *A* the *A*-line leads are attached to top group leads and the *B*-phase line is attached to bottom group leads. It is found on application of the arrow check that the connection is correct. In *B* all of the lines connect to bottom leads and this connection is also correct. In *C* all of the line leads connect to top leads. These three diagrams all have short or top-to-top jumpers and all of the connections are different, but they are all correct as may be found by checking them with the arrows.

The next two drawings *D* and *E* show top-to-bottom long-jumper connections. At *D* the short jumper which connects the two series of poles is connected ahead from group 5 to group 7. At *E* the short jumper is connected reverse from group 5 to group 3 in the same manner as in *U* of Fig. 7. Either one of these methods, *D* or *E*, is correct.

How Two-Parallel Connections Are Drawn

After a series connection has been drawn it is an easy matter to figure out how two-parallel connections should be made. A two-parallel connection is one in which there are two circuits for each phase. The number of groups in series per circuit is equal to the total number of poles divided by two. In any parallel connection each circuit must contain an equal number of groups and an equal number of active coils. Never attempt to parallel the coils in any one group. For instance, if coils 1 and 2 in Fig. 5, were connected in parallel circulating currents would be set up. This is because the two coils are out of phase by 45 degrees. At certain times the sides of coil 1 are in a stronger magnetic field than the sides of coil 2. Consequently there will be a higher voltage in coil 1 at these times which would cause circulating current to flow between the two coils. The proper way to parallel a winding is to put groups or series of groups in parallel with each other. Fig. 9 shows how a two-parallel connection is made from a series connection on a four-pole two-phase winding. Only one phase is shown here for the sake of simplicity. At *M* and *N* is shown the change for a top-to-top connection or short jumper. At *P* and *Q* is shown the change for a top-to-bottom connection or long jumper and at *R* is shown the two-parallel connection called "right-and-left." At *M* the series connection is shown for the top-to-top diagram and below it is shown the two-parallel connection. In the two-parallel connection the heavy lines show where the changes in jumpers have been made. It will be seen that it is necessary only to open the jumper between groups 3 and 5, then the bottom of group 3 is connected to the A_1 line and the top of group 5 is connected to the *A* line. This is the easiest way to change from series to two-parallel. All that is required is to cut the series of coils in half and connect the end of the first half to the outgoing lead and the beginning of the second half to the ingoing lead.

At *Q* is a two-parallel connection using the top-to-bottom or long jumper. This was made from the series connection at *P*. To get the two-parallel connection the series of four coils is cut in half at the short jumper between groups 3 and 5. Then the bottom of group 3 is connected to the *A* line and the bottom of group 5 connects to the A_1 line.

There is another type of two-parallel connection called the "right-and-left" connection. This is shown at *R*. Starting at the *A* lead the two parallel circuits pass respectively around the right-hand and the left-hand sides of the winding. One circuit starts at the top of group 1 and ends at the top of group 3. The second circuit starts on the *bottom* lead of group 7 and ends on the *bottom* of group 5. This type of connection is satisfactory for two-parallel but it requires considerable time and labor to reconnect it for series. The series connection is shown in the lower diagram in *S*. In order to change the two-parallel connection to series the first step is to disconnect the A_1 line from groups 3 and 5. Next the *A* line is cut off from group 7. Jumper No. 3 is then disconnected from the top of group 7 and connected to the top of group 3. Then the bottoms of groups 5 and 7 are put together. Now the top of group 7 becomes the A_1 line lead. The *B* phase is reconnected in the same manner.

It is obvious that considerable more time is required to change this type of connection to series than is required to get a series connection from the two-parallel windings shown at *N* and *Q*. For instance to change the two-parallel connections at *N* back to series it is necessary only to cut the top of groups 3 and 5 from their respective leads and connect these two groups together.

For these reasons the right-and-left type of parallel connection is not used to any great extent. The motor manufacturers try to use windings and connections which may be readily connected for two or more different voltages. This helps to reduce the stock of motors which must be carried in warehouses, etc. For example, a 440-volt motor may be designed for 440 volts with a series connection and carried in stock as a 220-volt motor connected two-parallel. If there is a call for a 110-volt motor or a 440-volt motor, this machine can be reconnected in a very short time in four-parallel for 110 volts or in series for 440 volts.

There are some nine-lead, three-phase and eight-lead, two-phase motors made which can be reconnected outside of the motor for two voltages. Diagrams of these connections and the method of checking them when the markings are lost will be given later on in this series.

The construction of diagrams for three-phase lap windings will be covered fully in the next section of this series of articles.

Record Forms for Motor Installations

(Continued from page 438)

and so on, those in the third row A^3, B^3, etc., and so on in this manner. Therefore the bearing with the figure 6219 J^1 will be found in bin J^1. In addition to this stamped number, each motor in the plant is painted with a white number. This number appears in the first column of the bearing chart. For instance, No. 20 appears on the first line. At the right of this will be found the other figure, 6219 J^1, which indicates the bin. The maintenance man therefore has only to remember the

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painted number. By locating this on the bearing record he can learn everything else he should know about the bearing.

Sometimes bearings are not carried in stock. For instance, in the second line of the motor record under "Bearings" there are no figures. The check marks indicate that there are no bearings in stock, as this motor is very old and of odd design and not on an important drive. The maintenance man will recognize this and will take the original bearing out for rebabbitting and boring.

In the last column of the motor record is a number to which the motor inspector refers to draw brushes out of stock. When a motor is put into service a proper grade of brush is assigned to it for its particular job. The brush is given a number and this is the number on the motor record sheet. Then this number is added to the brush chart, a copy of which is shown here. On this chart are the dimensions and shape of the brush and shunt and also a number indicating the grade of brush. A copy of this chart is sent to the manufacturer from whom brushes are purchased and whenever brushes must be bought they are ordered simply by giving the number and referring to the date on which the chart was submitted.

To make it convenient to use these records, a special method of mounting them has been devised. The motor sheets are placed in wooden frames as shown in the accompanying drawing. Two sheets are placed back to back with glass on both sides. Each panel accommodates four drawings, or 200 motors. The frames may be swung around so that any one may be examined.

Industrial Lighting Regulations

(Continued from page 451)

such regulations should always be too liberal rather than too restrictive. Is it not best to provide for the really bad conditions, avoiding unfair rigidity, even if some doubtful conditions are not wiped out? Such regulations can be strengthened when experience shows the need.

Some people seem to feel a desire to provide lighting legislation for all sorts of theoretical conditions. Since all legal regulations are expensive to enforce, involve inconvenience and cost to those subject to them and at best are likely to be more or less unfair through the inability to anticipate and describe all combinations of circumstances, it is important for the welfare of the public that enactment should be made only when a practical necessity dictates, and then should go only so far as the necessity requires.

Recent Movements in Formulating Lighting Legislation

About 1913 the Illuminating Engineering Society was invited to assist in formulating the lighting features of the Wagner Labor Laws in New York State. In this connection a group of lighting experts was brought together in a committee on lighting legislation. After two years of study and investigation a first set of specifications was produced, which with subsequent modification has formed the basis of the industrial lighting codes in the leading manufacturing states.

These codes developed some new principles of lighting legislation which rendered the work practically effective. First, it was recognized that the art of lighting was developing so fast that no definite set of rules could be expected to hold without changes for a long period of years. Therefore, it was found best to enact into law only a general statement of what it was desired to accomplish, delegating to a commission the power to adopt detailed specification of limits and methods. This avoids the cumbersomeness and delays of legislative action, and facilitates the adoption of regulations based on practical and scientific considerations with a minimum of political dictation. Developmental changes are more readily made, and yet excessive changes are prevented by individual responsibility and local hearings.

Another new principle was the incorporation of photometric units and more or less technical terminology, when necessary. Thus the rules were made more exact and definite, leaving less to personal judgment than before. Of course, such values and terms were not widely understood by those who were supposed to interpret the regulations, but it is surprising how soon the education regarding at least the practical application of "foot candle" and other designations spread. Even at this early date the codes can be more definitely interpreted than would have otherwise been possible.

The development of an inexpensive, simple, compact, light-weight, portable photometer, the foot-candle meter, remarkably accelerated this movement. Today any manufacturer has little or no difficulty in finding out whether or not he is complying with the industrial lighting code, or what changes are necessary to insure compliance.

When the industrial code had become fairly well standardized there came an insistent demand for a school lighting code.

The experience in connection with the industrial lighting code provided an excellent basis for formulating the school lighting code, the two classes of problems having much in common. The school lighting code of the Illuminating Engineering Society, a revision of which is now nearing completion, follows the lines of the Industrial Lighting Code.

Specifications of State and Other Lighting Codes

Most of the codes and regulations adopted by the various states have been authorized by commissions having jurisdiction over the activities in question. Usually the state law simply specifies that safe conditions must be maintained, and authorizes the commission to promulgate and enforce detailed rules to insure that end. The complaint is not infrequently made that codes do not require good practice in lighting—in other words, they are too lenient.

Such criticism emanates from a lack of understanding of the purpose of the codes and the powers of commissions. State Commissioners usually do not have the power to require the best or most efficient lighting, or even good lighting practice, from the standpoint of economic operation of a factory. They can only rule out dangerous lighting conditions, and the burden often falls on the commission to prove in court that any condemned lighting really is hazardous.

No state has assumed the power, in peace time, to demand of a manufacturer that he shall run his factory in such a way as to insure maximum over-all economy. So all the code can say is that the worker shall not be subjected to dangerous lighting conditions. A number of codes have pointed out in a recommendatory way the advantages of providing better lighting than can be required on the safety basis.

Each state has, of course, its own sovereign power and can adopt such

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code as it may think best. We of the industry can only suggest, and show reasons for or against proposed action. There is some basis for slight variation among state codes because of differences in local conditions, and advance is made by trying out innovations. However, it would be very unfortunate if each of the 48 states should adopt its own code, varying from all others.

There is, of course, a tendency to try and better what already exists—sometimes it appears to be done with a view to showing off. On the whole there is a remarkable unity in the action so far taken, which speaks well for the basic pattern furnished by the technical experts. In order to facilitate standardization of regulations throughout the country some of these regulations have been submitted to the American Engineering Standards Committee, representing the technical societies of the country, and accepted as American Engineering Standards.

How Chain Drives Increase Production

(*Continued from page* 437)

wherever motion is to be transmitted from one shaft to another, silent chain drives may be used to accomplish it economically, positively and with saving of space. All makers of chain agree on one point at least—that the field for application has not been anywhere near touched.

Every maker of chain has available data illustrating details of application and installation on not only the complete line of drives for all purposes, but also list prices and useful information for those interested and every user of motors or machines should be interested. Increased production, absolute ratio, short centers, slight vibration, easy alignment and high efficiency of transmission are some of the advantages claimed for silent chain drives.

EDITOR'S NOTE: Special acknowledgment is made to Earl C. Moss, Consulting Engineer, Chicago, Ill., and to the following companies for their kind assistance in furnishing information and photographs for this and the previous article on this subject: American High Speed Chain Co., Indianapolis, Ind.; The Baldwin Chain & Manufacturing Co., Worcester, Mass.; Cullman Wheel Company, Chicago, Ill.; Diamond Chain & Manufacturing Co., Indianapolis, Ind.; Duckworth Chain & Manufacturing Co., Springfield, Mass.; The Jeffrey Manufacturing Co., Columbus, Ohio; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; The Whitney Manufacturing Co., Hartford, Conn.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

A. W. Cadman Manufacturing Company, Pittsburgh, Pa.—Engineering Bulletin M-2 entitled "Bearings and Bearing Metals" gives some semi-technical information on what is required of a bearing, bearing bronzes, coefficient of friction, friction in bearings, heating effect in bearings, various bearing alloys, theory of lubrication, admissible bearing pressure, and other subjects. An interesting feature is a chart showing the relation of bearing temperature to speed and pressure.

Utilitool Company, 163 West Washington Boulevard, Chicago, Ill.—The "Utilitool" is a universal tool which is claimed to have sixteen different uses, for example as pincers, pliers, pipe wrench, screwdriver, monkey wrench, wire cutter, and others. This circular illustrates its use in these and other applications.

Clemson Brothers, Inc., Middletown, N. Y.—A 16-page booklet entitled, "Hacksaws and Their Use," is filled with facts concerning the properties and points which give quality and service to hacksaws.

Wayne Belting Company, Fort Wayne, Ind.—A folder entitled "Scientific Leather Belt Reclaiming" describes the Wayne process of reclaiming leather belting. This process involves cleaning and tearing apart old belting and rebuilding it.

Flexible Steel Lacing Company, 4607-31 Lexington Street, Chicago, Ill.—A small folder lists and illustrates each of the various sizes of Alligator steel lacing and also gives directions for applying it as well as some of the advantages claimed for this type of flexible lacing.

The Martindale Electric Company, 11,709 Detroit Avenue, Cleveland, Ohio—A small folder describes "Tasgon," a fluid used to dissolve rust and loosen rusty bolts, couplings, unions, bushings or other rusted connections.

Bussmann Manufacturing Company, St. Louis, Mo.—A small booklet entitled "Fuseology" which is a treatise on fuses and fuse protection, covers such subjects as: What is its use; why such a safety valve is necessary; where to look for trouble when a fuse blows; correct size to use; requirements of Underwriters; how a fuse operates, and other interesting and valuable data.

C. J. Tagliabue Manufacturing Company. 18-88 Thirty-third Street, Brooklyn. N. Y.—A circular describes the "TAG-Hespe Red Reading Column" for mercury thermometers. These are made with a red line behind the mercury tubes so that the red line attracts the eye and shows definitely the division between the red line and the top of the Mercury column. This makes reading easy.

The Nitrose Company, Peoria Life Building, Peoria, Ill.—Circulars describe "Nitrose" which is a glossy paint for metal exposed to the weather, high temperatures, moisture, brine, ammonia, sulphur or acid fumes. It is claimed that the film is elastic and rust defying and that the paint may be applied over rust, grease, or moisture and will attach itself to the sound metal. This paint is made from a chemically-treated, coal tar base, which, it is claimed, does not separate.

Mercury Manufacturing Company, 4118 South Halsted Street, Chicago, Ill.—Bulletin A-100 describes the Mercury Type A-310 trailer with a carrying capacity of 4,000 lbs. for use with industrial tractors as an all-purpose industrial trailer. The two front wheels are ball-bearing casters with ball-bearing hubs. A special steel hook hitch and towing eye are attached.

Chas. A. Schieren Company, 30-38 Ferry Street, New York City—A folder on the Schieren rawhide belt lacing not only illustrates both the standard method and the hinge method of lacing belts with rawhide, but also gives a set of instructions which include the length of lace, the number of holes to punch, the size of the hole and other information for different widths of belt.

Crescent Belt Fastener Company, 381 Fourth Avenue, New York City—A small folder entitled "Away from Methuselah" treats in a humorous way the origin of belts and the belt troubles which led up to the development of improved methods of joining belts. In addition, the pamphlet contains instructions for applying the various sizes of Crescent fasteners as well as where and when to use them and twelve advantages claimed.

The Yale and Towne Manufacturing Company, Stamford, Conn.—A folder on the "Yale Steel Plate Trolley" with roller bearings, which is used to carry a hoist on an I-beam monorail, illustrates, in addition to the construction features, many applications of Yale hoists and trolleys in a variety of industries. Also, the complete line of the Yale material-handling equipment is listed.

The Standard Electric Tool Company, Cincinnati, Ohio—A series of loose-leaf bulletins in a special folder describes and illustrates various applications of the Standard high-power, portable electric drills, reamers and grinders, including universal drills for operation on both alternating and direct current.

Laurence Belting Company, Inc., 111 Chambers Street, New York City—A group of folders describes the various types of waterproof Laurence leather belt.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

October, 1923

McGraw-Hill Co., Inc. Chicago, Ill.

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ou have got the very utmost
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The Packard Electric Co.
WARREN, O.

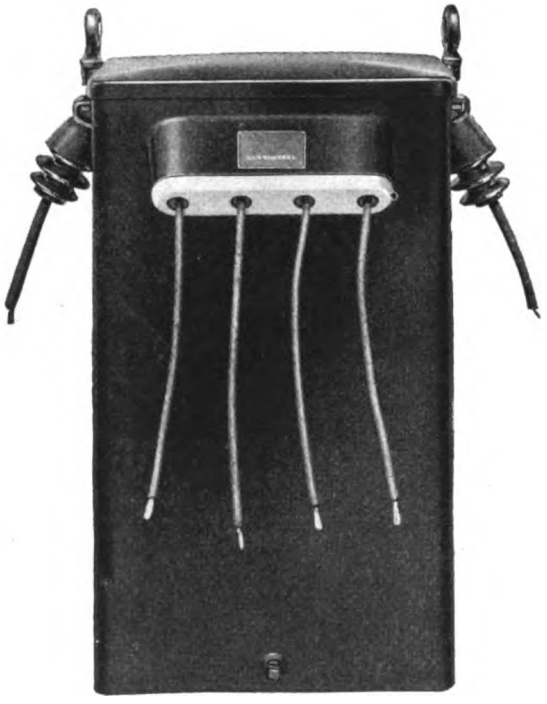
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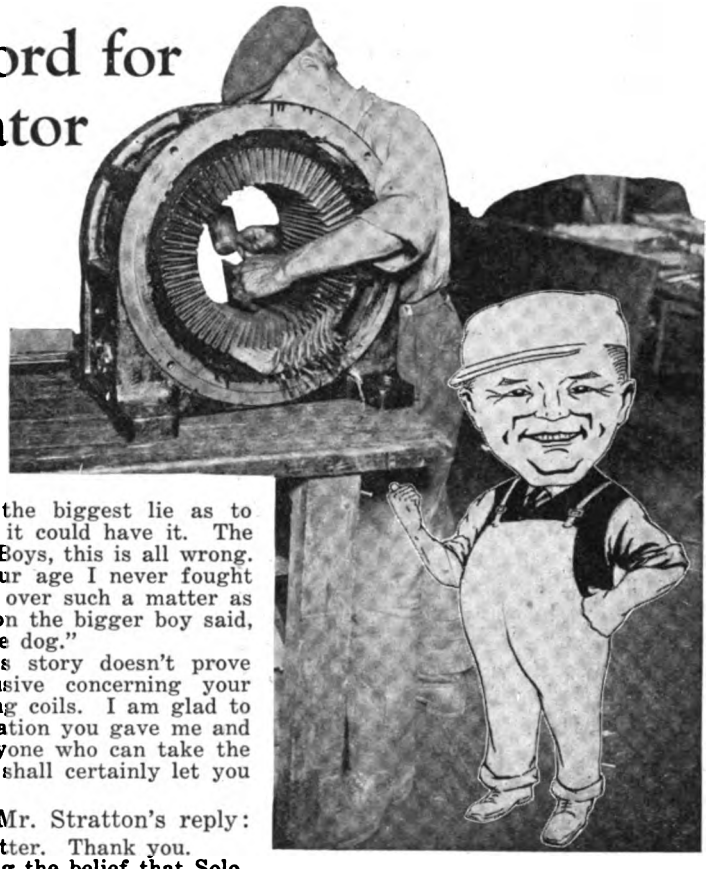
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, October, 1923 *Number 10*

What's Your Best Record for Inserting Coils In a Stator

And completing the job ready for making the end connections of the coil groups?



ON A TRIP through the South some time ago I chanced to visit the repair shop in Charlotte, N. C., operated by L. F. Stratton and his two sons. After seeing some time- and money-saving methods in making coils, stripping armatures, inserting coils in stators and the like, I had a good, long talk with L. F. Stratton himself—a treat I am going to give myself again soon, for in a couple of hours he told me more things about repair shop work that is right and wrong than any one I have met in a long time.

After returning to my own job I rolled over in my mind the details of a job that Mr. Stratton told me about, which concerned a time test for inserting forty-eight coils in the stator of an old-style G. E. motor. In a letter I asked him to check my memory that the time for *completing the job* was one hour and forty-three minutes. In reply he gave full details and stated that the time mentioned was correct for inserting the coils with the insulation cut and inserted before starting and the coils taped at the ends. I then wrote Mr. Stratton the following letter which drew the masterpiece quoted below:

DEAR MR. STRATTON:

I have read your letter twice already and am going to read it again as soon as I can find the time. I recall with decided pleasure my visit with you and I want to assure you that I shall try to work out the problems we discussed and write you about my own troubles, knowing that I will get a real reply.

In reference to the time it took you to insert 48 coils in a 5-hp. motor I recall the story of two boys who were found by a good preacher on the street fighting over a dog. Upon inquiring the cause of the trouble one boy said that they had found the dog and decided that the fellow who could tell the biggest lie as to how they found it could have it. The preacher said, "Boys, this is all wrong. When I was your age I never fought with other boys over such a matter as this." Whereupon the bigger boy said, "Mister, take the dog."

Of course this story doesn't prove anything conclusive concerning your speed in inserting coils. I am glad to have the information you gave me and if I discover anyone who can take the dog from you I shall certainly let you know.

And this is Mr. Stratton's reply:

I have your letter. Thank you.

After nurturing the belief that Solomon had nothing on my wife's husband, except the number of wives he annexed, I am more than ordinarily offended when you tell me you read my letter twice, and that another reading will be necessary (we assume) to get any sense out of it. This is the most violent jostle that my ego has had recently, and you'll better understand what that means when I tell you that I have been married thirty-four years, and that Mrs. Stratton is a Missourian.

The pup, the belligerent kids and the Eminent Divine appear to be made especially to fit my case. I never did have a fondness for mutts; so let 'em have the dog, I don't care. I learned long since that if you cherish an ambition for a prevarication diploma you must restrain your desire to go over the top until the last man has placed his cards—all of 'em—face up on the table. I'm more than ordinarily expert (sure 'nuf) when the necessity or desire attacks me to run the whole Gamut, Chromatic Scale and all, in distorting the facts, but my experience has demonstrated that it's only the last man at the bat who has a ghost of a show as a liar of merit.

However, the scientific and speculative side of electricity rather demands that we use two crutches or nothing less than a crutch and cane if we walk at all. The mechanical side appeals to us, including motion studies and the elimination of gestures that count only in the weekly pay sheet or result in the prolongation to two hours of a job that should take as many minutes.

We still remember you as among those it would be a delight to see frequently. With best wishes.

I want to go to Charlotte soon and if any reader thinks he has Mr. Stratton beaten on inserting forty-eight coils in a stator, I would like to get the details of the job. And by the way, if you are ever near the Stratton shop make it a point to drop in and call for L. F. S. himself—you will have a good time and get both eyes and ears full of things you would like to know.

Practical Pete

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A Glimpse into the

Works of The Pullman Company

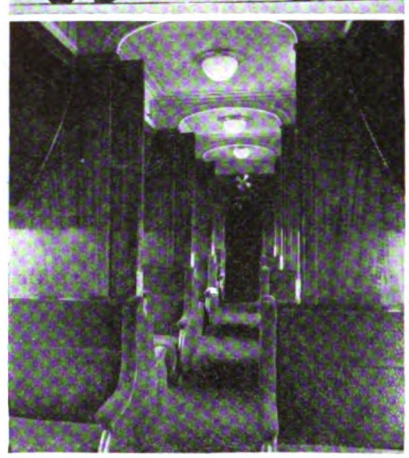
Where a plan for increasing comfort of travel has resulted in a large manufacturing and operating organization. The ninth of a series devoted to the growth and extent of our basic American industries.

IN THE early days of railroad travel the lines were short and at first it was thought impossible to operate trains at night. The first sleeping car, in 1836, consisted of a day coach divided into four compartments, each with a row of seats along one side and three tiers of berths or bunks without bedding along the other.

In the early fifties George Mortimer Pullman was impressed during a night trip with the advantages to the traveling public of a service contributing safety, convenience, luxury, and a thorough and uniform service even though on a long journey. It was not until 1858 that he had the opportunity to apply his ideas to tests, when a Chicago & Alton passenger coach was made over into a sleeper—historic "No. 9." This introduced Mr. Pullman's invention of upper berths which might be closed in the daytime and serve as receptacles for bedding. From this small beginning, many improvements have been made in convenience, comfort and safety through six-wheel trucks, electric lights, all-steel anti-telescoping frames and other features.







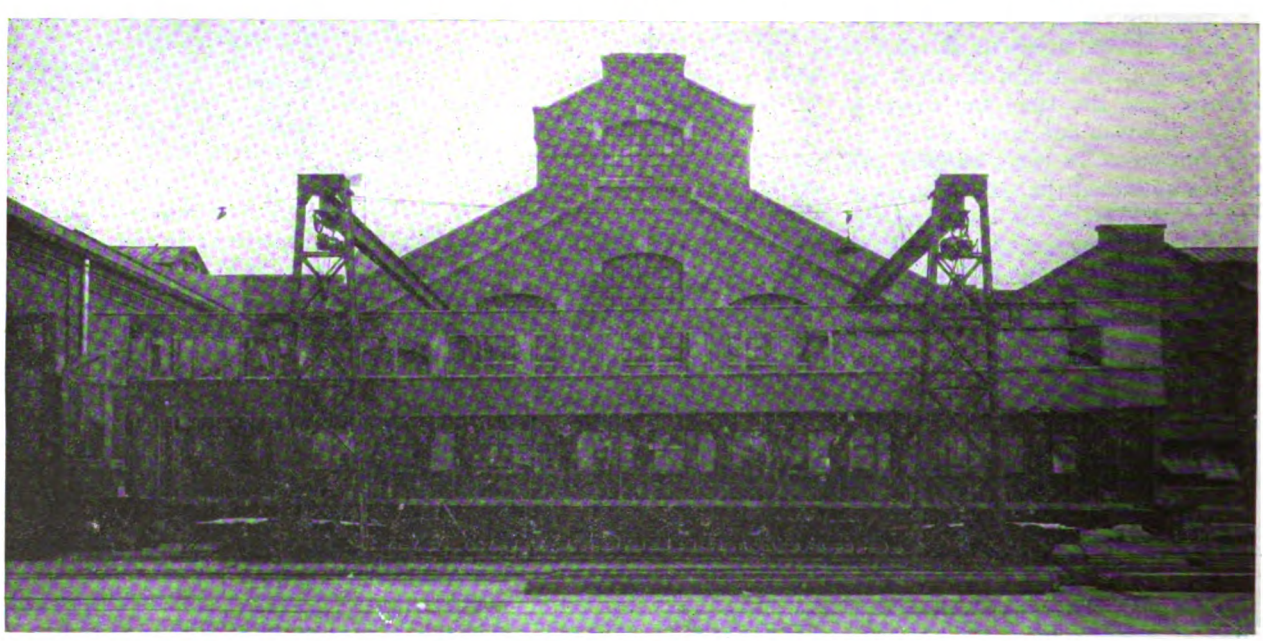
How the first Pullman car compares with one of today.

The first Pullman, "No. 9," was made from a rebuilt passenger car. In this the upper berths were suspended by ropes and pulled up overhead during the daytime. From this basic idea has evolved the modern, all-steel Pullman. The interior view shows the new type of day-time semi-privacy sleeper with permanent partitions between berths making semi-compartments of sections.

The next step was the organization of departments to manufacture and operate these cars over many railroads. Today, Pullman service extends over practically the entire United States. The longest run is between Washington, D. C., and San Francisco, Calif., a distance of 3,606 miles. The Pullman Company supplies a reservoir of cars for handling un-

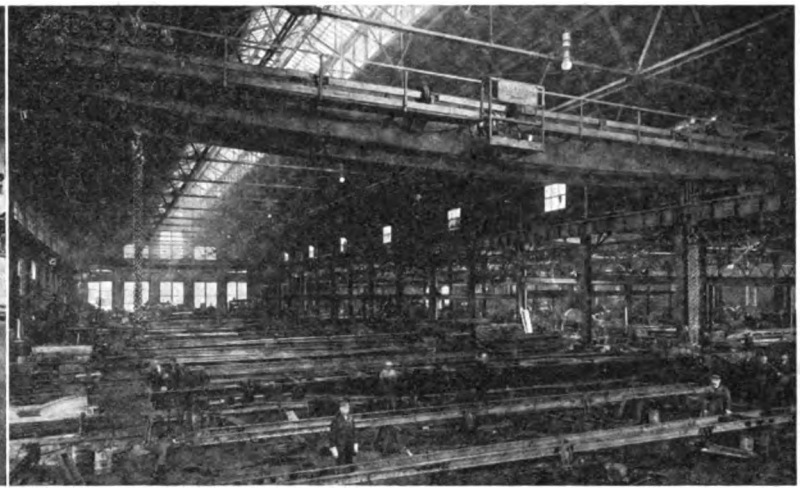
Placing the whole side of a Pullman car in position.

One of the most interesting operations in the construction of a Pullman car consists in the method of building the body. The underframe is assembled on trucks as shown below. Both sides and the top are assembled in special jigs or templets, lifted by two hoists, as shown here, slipped into position and riveted.



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Two extremes in fabrication.

The view at the right shows the fabrication of the steel framework which gives strength and safety to the car. All the interior except the upholstery, bedding, and similar material is of steel. The view at the left shows some of the miscellaneous sewing required.

usual or peak service. About 5,864 of its 7,665 cars are in daily service with over 1,000 more required during peak travel periods.

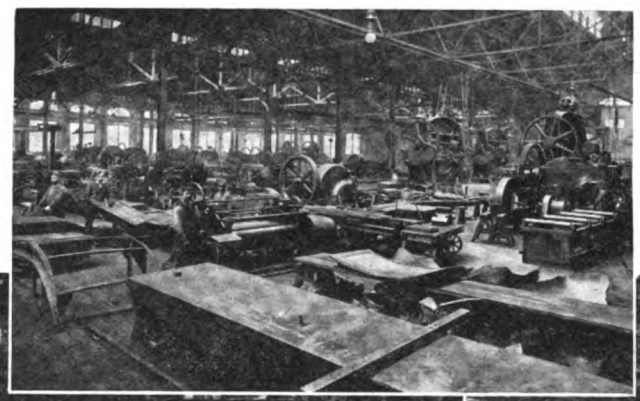
The Operating Department has 23,500 employees of whom about 10,000 are porters. Another 4,000 are employed as car cleaners and 4,000 additional in repairing cars. Over 300,000,000 pieces of linen are laundered each year.

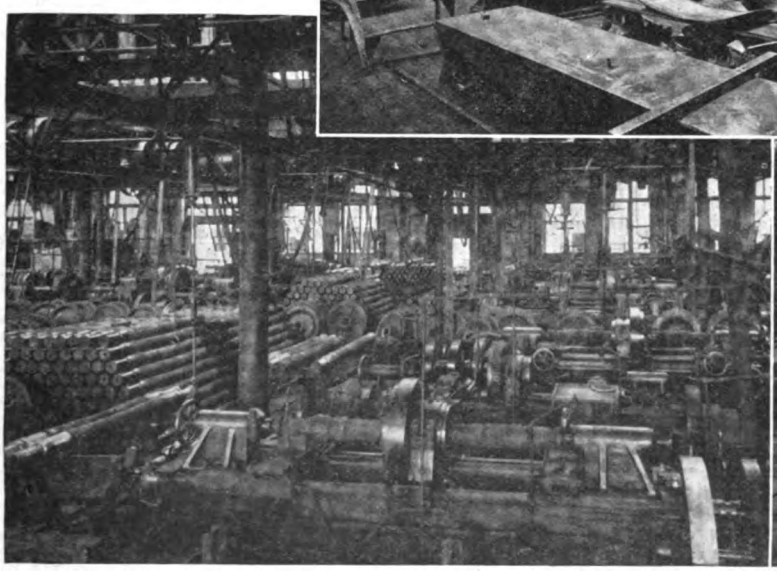
In the manufacturing organization 10,400 people are employed in building both passenger (in addition to Pullman) and freight cars in the 150 factory buildings covering 600 acres of land. Including the Haskell & Barker plant at Michigan City, Ind., and the Pullman plant in Chicago, The Pullman Company can build monthly 3,500 new freight cars and repair at its shops 375 in addition, as well as build 125 passenger cars.

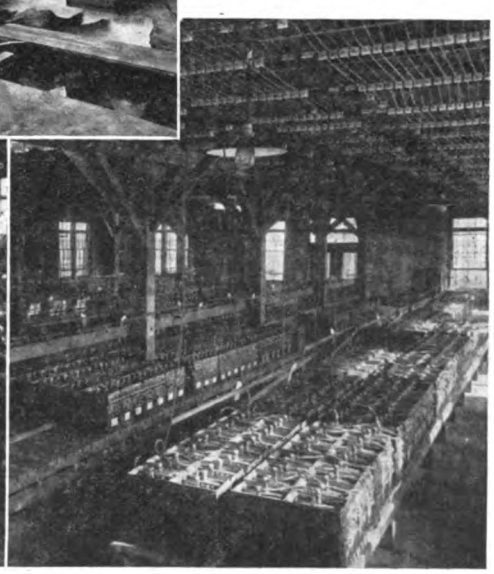
Freight transportation produces two-thirds of all revenue of the railroads — about $4,320,000,000 out of $6,225,000,000. In 1919 over 1,100,000,000 passengers were hauled an average of about 41½ miles. For this all railroads received about $1,250,000,000. During the past year Pullman cars carried an average of 90,000 passengers daily approximately 375 miles per trip. The net operating income last year was about 24 cents per Pullman passenger or $2.84 per day for each car owned.

Three views in the Pullman shops.

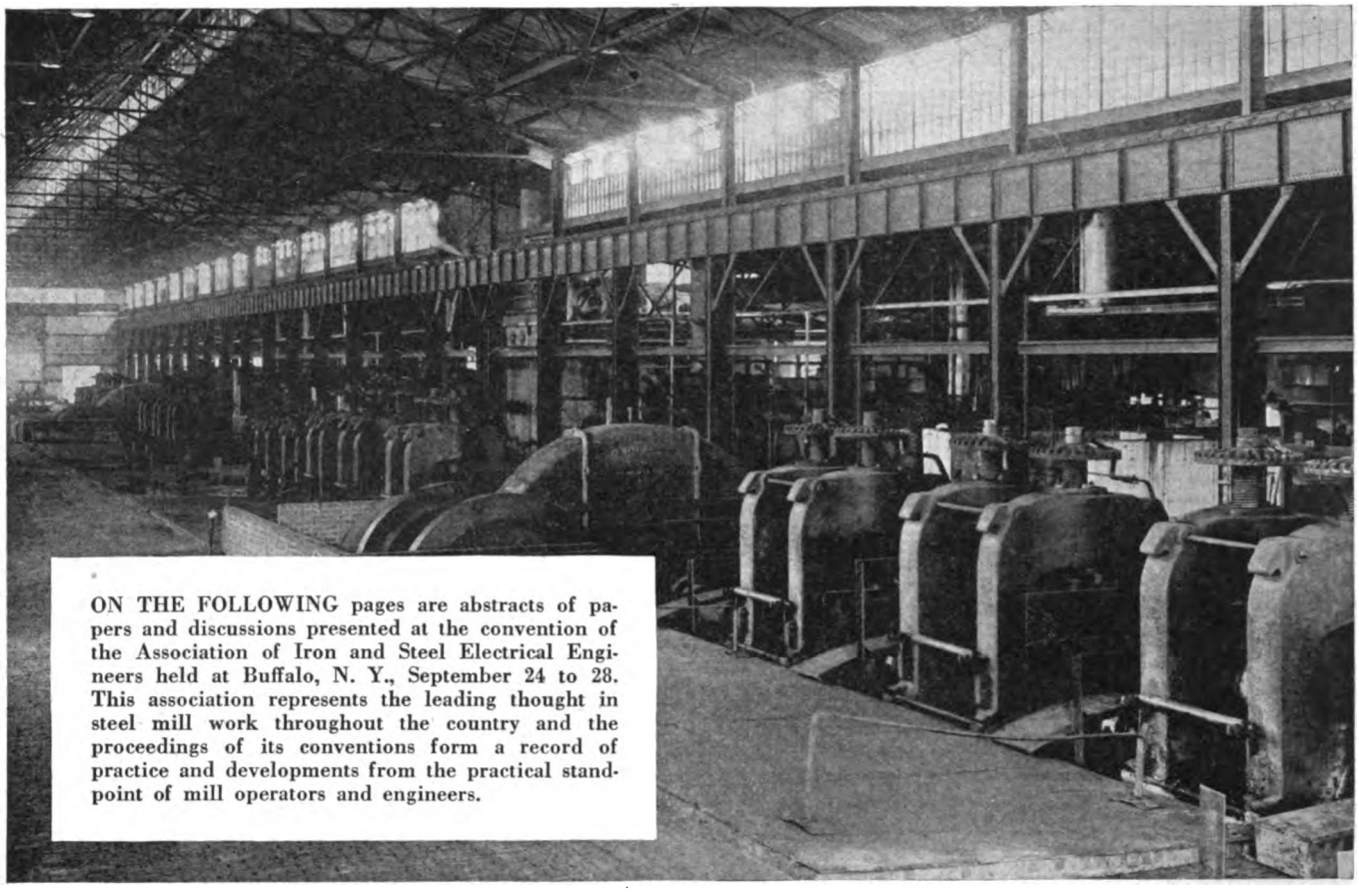
Each of the plates used in the side of a Pullman car is laid out and punched according to a templet, so that when assembled all will fit together perfectly. The view below, shows the axle shop. Special lathes drive the axle from the center so that tools can work on both ends at the same time. The view at the right shows the battery-charging department of the Calumet repair shop, where a large variety of miscellaneous repairs and refinishing is handled. About 4,000 men are employed in this work regularly. In addition there are sixteen linen repair shops and several general and division storehouses.







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ON THE FOLLOWING pages are abstracts of papers and discussions presented at the convention of the Association of Iron and Steel Electrical Engineers held at Buffalo, N. Y., September 24 to 28. This association represents the leading thought in steel mill work throughout the country and the proceedings of its conventions form a record of practice and developments from the practical standpoint of mill operators and engineers.

Some of the

Problems of Steel Mill Operation

Which Are Now Faced or Have Been Successfully Worked Out in Practice During the Past Year or Two

AT THE seventeenth annual convention of the Association of Iron and Steel Electrical Engineers, held in Buffalo, N. Y., September 24 to 28, papers were presented on a wide variety of subjects of interest to men in charge of blast furnace, rolling mill and associated operations. These papers presented the viewpoint of the operating electrical and mechanical engineer, and their authors represented the following companies: Carnegie Steel Co., Bethlehem Steel Co., Babcock & Wilcox Co., Inland Steel Co., Ohio Steel Foundry Co., Minnesota Steel Co., Worth Steel Co., New Jersey Zinc Co. and Halcomb Steel Co.

In what follows abstracts are given of papers dealing with electrical and associated mechanical systems, with main points of the discussions.

Electrical Development Committee

By WALTER C. KENNEDY,

Chairman and Operating Engineer, Worth Steel Company, Claymont, Del.

THE Electrical Development Committee reports submitted each year and published by this association are intended to note the developments occurring during the respective years. The report then is intended to cover developments that have become active or particularly noticeable during the past year.

The subject of ever-absorbing interest to the steel mill electrical engineer is the rapidly increasing list of main-drive applications. Since the very first installation of this kind this list has been rapidly growing from various causes and this year has been no exception to the rule. Sixty-two installations are recorded in an accompanying table.

There are many interesting features in connection with the installations, but there seems to be three prominent features that should be called to our attention:

1. The large number of motors replacing steam engines.
2. The extent to which gears have been used.
3. The use of direct current exclusively on several adjustable speed applications.

It is gratifying to know that the electric drive has so far proven its

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superiority in regard to economy of operation that it is now replacing more than ever the steam-engine-driven equipments. When we consider that the first electric drive for a reversing mill, to replace a steam engine, was sold in 1917 to the Lackawanna Steel Company, but which was not put into operation until 1921, the growth for this line of work especially has been phenomenal.

The rapid increase in the use of electric drive may be due to three causes:

1. The increasing cost of coal and, therefore, steam.
2. The increasing availability of reliable purchased power.
3. The development in gear drive.

All of the above developments, of course, have been gradual, but it is now a recognized fact that in many cases a steel plant may buy purchased power at a better figure than they can make it and at the same time reliable enough to be considered for steel mill service. In many cases steam engines would probably not have been replaced had it not been possible to purchase power.

In regard to the third reason, purchased power is in nearly every case 60-cycle if purchased from any of the public utility companies. For main roll equipment the use of 60-cycle power practically means a gear reduction, and here is seen one great development in this art which has required several years to accomplish. At one time a gear reduction on a main rolling mill drive was a questionable point, but now this form of drive, through its development, has become so reliable that there is no further question as to its use for this service. In many cases the flywheel is directly mounted on the motor shaft and the gear reduction, therefore, has to stand severe shocks of rolling. Even these equipments have given good service and, therefore, the success of the gear drive has really helped to a large extent to increase the number of motor applications through the use of purchased 60-cycle power.

Referring to the various items, there are several points of interest to be noted.

Plants 7, 14, 19, 20, 22, 40, 41 and 51 replaced steam engines. Operators are realizing more and more that they cannot afford to keep these old steam engines in operation. They are inefficient in their use of steam and require constant attendance and maintenance. It is not an uncommon thing from saving of attendance, maintenance and repairs to more than pay for the fixed charges on the electrical installation, leaving a saving in power consumed as sure profit. The steam-driven mill is slowly but surely being supplanted.

Plants 19, 20, 21, 30, 40 and 60 are of interest as being geared drives of large capacity. A 6,250-hp. installation for Inland Steel Company will be the largest geared drive in this country. It was formerly the practice to direct connect the driving motor to the lay shaft on continuous mills. On late installations, however, most of the drives are geared.

Plants 7, 40, 58 and 59 are drives of the Ilgner type, consisting of direct-current motors supplied with power from flywheel motor-generator sets. The drives for the Cia Sederurgical del Mediterraneo at Sagunto, Spain, are only part of a large order including all electrical equipment

Steel Plants Now Using Electric Motors on Main Drives

No.	Company	Motors No.	Motors Hp.	Volts	Cycles	R. p. m.	Mill	Connection
1	Am. Rolling Mill Co.	2	2000	6600	60	505	Rolling	Gear
2	Am. Rolling Mill Co.	2	600	2200	60	885	Rolling	Gear
3	Am. Rolling Mill Co.	2	500	2200	60	575	Rolling	Gear
4	Am. Rolling Mill Co.	4	400	2200	60	575	Rolling	Gear
5	Am. Rolling Mill Co.	10	300	2200	60	575	Rolling	Gear
6	Atlas Steel Corp.	1	700	240dc		135/360	10-in. Merchant	Direct
7	Bethlehem Steel Corp.	1	7000	700dc		0/120	40-in. Blooming	Gear
8	Bethlehem Steel Corp.	1	300	2200	25	750	10-in. Bar	
9	Buckeye Rllg. Mill Co.	1	1000	4000	60	720	18-in. Rail reroll.	
10	Calumet Steel Co.	1	400	4000	60	585	Slitting stand	Gear
11	Columbia Steel Co.	1	1500	2200	60	360	Sheet	
12	Columbia Steel Co.	1	1800	2200		514	Rod	
13	Dilworth Porter	1	700	2200	60	390	18-in. Bar	Gear
14	Firth Sterling Steel Co.	1	550	250dc		120/300	10-in. Merchant	Direct
15	Follansbee Bros. Co.	1	500	2200	60	442	Cold Sheet	Gear
16	Holcomb Steel Co.	1	620–200	440	60	321/107	9-in. Merchant	
16A	Holcomb Steel Co.	1	500–250	440	60	130/65	14-in. Merchant	
17	Ford Motor Company	1	8000	13200		240	Blooming	Direct
18	Ford Motor Company	1	4500	500dc		67½/110	14-in. Merchant	
19	Illinois Steel Co.	1	5000	6600	25	370	132-in. Plate	Gear
20	Illinois Steel Co.	1	5000	6600	25	370	90-in. Plate	Gear
21	Inland Steel Co.	1	6250	2200	25	368	24-in. Cont. billet	Gear
22	Inland Steel Co.	1	1500	2200	25	368	Sheet bar finish	Gear
23	Inland Steel Co.	1	4500	2200	25	300/500		
24	Inland Steel Co.	1	4500	1500dc		67½/110	14-in. Merchant	
25	Jones & Laughlin	1	5750	6600	25	94	18-in. Billet	
26	Jones & Laughlin	1	5750	6600	25	94	21-in. Billet	
27	Knoxville Iron Co.	1	800	2200	60	900/720	9-in. Merchant	
28	Metal & Thermit Corp	1	1300	4000	60	360	Sheet	
29	Michigan Steel Co.	1	1500	4600	25	300	Sheet	
30	National Stamping & Enameling Co.	1	3000	2200	60	235	100-in. Plate	Gear
31	Newton Steel Co.	1	2000	2200	60	234	Sheet	Gear
32	Newton Steel Co.	1	300	2200	60	340	Cold sheet	Gear
33	Otis Steel Co.	1	6500			0/120	40-in. Reversing blmg.	Direct
34	Otis Steel Co.	1	1800	6600	25	500	20-in. Strip	
35	Otis Steel Co.	3	1500	600dc		280/420	20-in. Strip	
36	Otis Steel Co.	3	1800	600dc		115/230	20-in. Strip	
37	Otis Steel Co.	1	3000	6600	25	375	24-in. Sheet bar	
38	Otis Steel Co.	5	375	230dc		430/860	Cold strip	Gear
39	Otis Steel Co.	1	350	2200	25	240	Cold strip	Gear
40	Phoenix Iron Co.	1	3000	600dc		0/485	24-in. Structural	Gear
41	Phoenix Iron Co.	1	2500	2200	60	500	22-in. Bar	Gear
42	Pgh. Crucible Steel Co. Midland, Pa.	1	2500	6600	25	150	Billet	
43	Standard Underground Cable Co.	1	300	2200	60	575	Rod	Gear
44	Takata & Company.	1	1000	2200	60	293	Sheet	Gear
45	Timken Roller Bearing Co.	1	800	230dc		410/720	16-in. Roughing	Gear
46	United Alloy Steel Co	1	360	230dc		300/600	Merchant	Direct
47	Youngstown Sheet & Tube Co.	1	2000	2200	60	234	Sheet	Gear
48	Youngstown Sheet & Tube Co.	1	400	220	25	375	Tube	
49	Youngstown Steel Co	1	1200	2200	60	505	29-in. Roughing	Gear
50	Youngstown Steel Co.	1	1500	2200	60	705	24-in. Finishing	Gear
51	Washburn Wire Co.	1	1000	2200	60	710	20-in. Blooming	Gear
	COPPER AND BRASS MILLS							
52	Am. Insulating Iron & Cable Co.	1	600	440	60	360		
53	Am. Insulating Iron & Cable Co.	1	600	440	60	900		
54	American Brass Co.	1	500	2200	60	600		
55	Taunton New Bedford Copper Co.	1	500	2200	60	600		
56	Western Cartridge Co	1	600	2200	60	514		
57	Western Cartridge Co	1	500	2200	60	514		
	FOREIGN							
58	Cia Siderurgica Del Mediterraneo	1	5000	700dc		0/120	40-in. Blooming	Direct
59	Cia Siderurgica Del Mediterraneo	1	3750	700dc		0/150	24-in. Structural	Direct
60	Cia Siderurgica Del Mediterraneo	1	3000	5250	50	735	36x111-in. Plate	Gear
61	Consolidated Rolling Mills, Mexico	1	300	3000	50	750	16-in. Mcht. roughing	
62	Consolidated Rolling Mills, Mexico	1	500/250	3000	50	750/375	10-in. Mcht. finishing	

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complete for these mills: rotary converters, auxiliary motors, control and switching apparatus. The 24-in. structural mill drive for the Phoenix Iron Works is of the Ilgner type, although it will not be reversed in ordinary operation. This type of drive allows the operator to slow the mill down to enter a piece, and then finish at a high speed, thus increasing the tonnage materially. All previous installations of this type and size have made use of direct-connected motors.

During this year the largest a.c. and single-unit d.c. motors for operating main rolls have been purchased by the Ford Motor Company, items 17 and 18. The former is an 8,000-hp., 240-r.p.m., 13,200-volt, slip-ring induction motor, which will be used to drive an interrupted continuous blooming mill built by the Morgan Construction Company. Incidentally, this is the first steel mill induction motor operating at a voltage exceeding 6,600 volts. The single-unit d.c. motor is rated 4,500-hp., 67½/100 r.p.m., 500 volts, and will be used to drive a 14-in. merchant mill. Direct-current power for this motor is supplied by two 2,000-kw., 250-volt synchronous motor generators, the two generators being connected in series to give 500 volts for the motor armature. The synchronous motor driving the 2,000-kw. generator is rated 2,800 kva., 8 pf., 13,200 volts. Excitation for the synchronous motor and d.c. motor fields is obtained from a third 2,000-kw., 250-volt motor-generator, which also supplies some power for auxiliary motors. A fourth duplicate motor-generator is held as a spare.

The largest induction motor with Kraemer system of speed regulation was also purchased during the year by the Inland Steel Company, Indiana Harbor, Ind., item 23. This motor, which will drive a 14-in. merchant mill, is rated 4,500 hp., 300/500 r.p.m., 2,200 volts, 25 cycles.

The electrical equipment for driving the 30-in, reversing Universal skelp mill at the plant of the Youngstown Sheet and Tube Company, which was reported last year, has been installed and is now in operation. This motor replaces a twin simple reversing engine and its performance so far indicates that when the additional continuous reheating furnaces are completed the tonnage records made by the engine will easily be exceeded. The roll motor is a double-unit motor, rated 4,000 hp., continuously, 80 r.p.m. and 11,500 hp. maximum at 75 r.p.m. The maximum speed is 135 r.p.m. The flywheel set consists of a 2,500-hp., 6,600-volt, 25-cycle, 500-r.p.m. induction motor, two 1,800-kw., 650-volt d.c. generators and a 78,000-lb. steel plate flywheel.

The equipment for the Holcomb Steel Company, items 16 and 16A, is of interest in that it covers the first polyphase brush shifting a.c. motors for main roll drives. This type of motor has been developed and applied to other work, as was previously recorded in the 1922 report, but the above installation is the first one being applied to mill drives. Speed control is obtained by two sets of brushes, whose relative position on the commutator is altered by means of a motor-operated brush shifting mechanism. This motor has characteristics practically identical with the double-range Scherbius equipment and fills a long-felt want for an adjustable-speed a.c. drive where the power required is too small to make Scherbius or Kraemer apparatus feasible on account of the high initial cost of very small installations.

As mentioned in last year's report, the tendency towards simplicity of apparatus is still very pronounced. Instead of using complicated arrangements or special a.c. motors for speed variation, the tendency still seems to be toward the installation of d.c. drives, of variable-speed motors and motor generator sets.

Improvements have been made in details of construction of breakers to meet increased mechanical duty imposed by the interruption of heavy power circuits and the severe strains due to tremendous magnetic forces set up by the short-circuit currents occurring in these circuits. These magnetic strains tend to distort conducting members and supporting insulators and disarrange contact details. The interruption of heavy current flow produces severe explosive forces which must be controlled and relieved. The circuit breaker structures have been made adequate for these conditions, which have been determined by extensive field tests. Provision has also been made for the relief of the expulsion of large quantities of oil, which in the past has been a hazard to property and life.

Expansion of the idea of phase isolation in large power plants has also been prominent and several installations of vertical, isolated-phase circuit breakers are under construction. The use of truck-type circuit breakers in which the entire circuit breakers may be wheeled in and out of a compartment and automatically connected to or disconnected from the circuit is extending rapidly in certain services of the more moderate capacities. Considerable activity has also been shown in extremely high voltage work, 220,000-volt breakers having been put into service on systems on the Pacific Coast, while a large number of 154,000-volt breakers has been produced.

The use of electric heating in the iron and steel industry is still continuing to show advancement and development along some novel lines. We have ordinarily considered that electric power for this service in the steel plant has been applied or is more adapted toward making steel in some form of the electric-arc furnace. However, some new applications along this line have come to the front during the past year.

In the July issue of the 1923 proceedings, an adaptation of electric heating on finishing rolls of sheet and tin plate mills was presented by Mr. Gordon Fox. The purpose of such heat is to prevent roll breakage; and, from all accounts from the results obtained, it has been very successful. The principle is one which no doubt would be well adapted to other cases. Further details will not be considered here in this report, but those interested can obtain much valuable information from the July issue referred to above. The method is new, convenient and economical. The application and operation can be so governed as to offer considerable possibility for decrease in roll breakage.

There has also come to our attention this year a very important and interesting application of electric heat for the purpose of generation of steam by electricity. The electric steam boiler or generator is not exactly new, having been used in various parts of Europe for several years, but its development in this country has been within only the last two years and the last year especially has seen the development of large units heretofore not conceived possible or practical. The development in this country has so far exceeded that of any European practice and has occurred along such novel lines that boilers are now being produced which are to be found nowhere

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else in the world. This subject has been very capably presented by Mr. P. H. Falter in the July, 1923, proceedings of this association. The electric steam generation has been particularly adaptable where large amounts of power are produced or purchased and where the question of load factor is of prime importance. While ordinarily it would be assumed that they would be of particular service on purchased power, still the developments are now showing that their use is increasing even where electric power is generated at the plant, especially where it is economical or advantageous to keep the load factor constant.

The Brown Company at Berlin, N.H., Mr. George P. Abbott, electrical engineer, have recently installed one three-tank boiler, operating at 22,000 volts, 3-phase, 60-cycle. This boiler is rated at 18,000 kw., or approximately 1,800 b.h.p., producing 54,000 lb. of steam per hour. The Brown Company generate their own power from a hydro-electric power station and it is transmitted to their mills at 22,000 volts, the boiler operating directly on this voltage without the necessity of transformers. The above equipment is intended to operate only on Sundays and other holidays so that an operation of approximately sixty days per year has justified its cost and use.

The resistance furnace still continues to improve and these furnaces are being used regularly on the vitreous enameling processes, which require a higher temperature than that previously obtained with this type of furnace.

High temperature heating elements for installation in modified fuel-fired furnaces are under development.

One of the outstanding developments of the past year is the auto-valve lightning arrester. This is a valve-type arrester, designed for the protection of both line (Type "LV") and station (Type "SV"). It consists of one or more columns of discs separated by minute air gaps. These gaps impart the valve characteristics, as several hundred volts are required to maintain a discharge across each gap. No maintenance is required by this arrester, and only infrequent inspection. It contains no liquid nor any solid dielectric in the path of the discharge. Its operation involves no chemical reaction and is not affected by temperature.

The distribution type is designed for pole, wall or cross-arm mounting. It is light-weight, easily installed and has no live parts exposed. This is the first valve-type arrester ever offered for distribution service. The station type may be placed on any suitable base, in or out of doors. It is unusually small, and compact.

The static condenser has been applied within the last few years to comparatively small power equipments for the purpose of increasing the power factor. While the results have been entirely satisfactory, still much remains to be developed in the way of standardization and adapting such condensers for ordinary commercial work. Development of this line of apparatus has now reached a high state of perfection. A complete line of static condensers for two and three-phase, 2,300 volts, has been developed in four standard unit assemblies—30, 60, 90 and 120 kva. The outstanding feature of this new condenser is its reliability. It is able to withstand all line surges and conditions of over-voltage equally as well as a distribution transformer. Working stresses have been adopted, which places this condenser on the same basis as oil impregnated cables, as far as reliability is concerned. All manufactured units are given the A. I. E. E. test of 2¼ times normal voltage plus 2,000 for one minute.

Special Bearing Committee

By D. M. PETTY,

Chairman and Electrical Superintendent, Bethlehem Steel Company, South Bethlehem, Pa.

THE COMMITTEE on bearings has, during the past year, made a careful study of the problem of applying roller and ball bearings to motors. It has held one joint meeting with a committee representing the Power Club and appointed to study the same problem.

The following are some of the high spots which have come out in this discussion, classified according to: (1) Users of motors; (2) builders of motors; (3) builders of bearings.

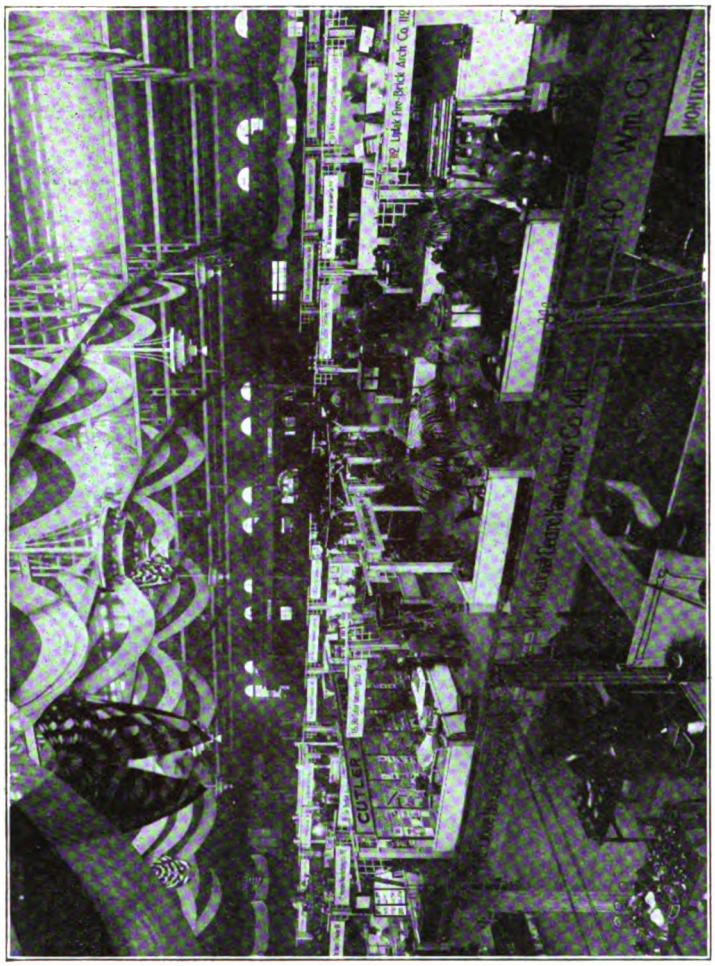
A relatively small class of the users of motors have used ball or roller bearings in motors. A vast majority of this class are very enthusiastic over the results obtained. They have had some bearing failures, but have been able to satisfactorily explain these failures and rather definitely fix the causes as follows: (1) Improper mounting; (2) improper size of bearing; (3) grounded armatures. With ball bearings a smaller number of armatures are grounded in a given length of time. (4) Improper lubrication, which may be divided into: (a) Improper lubricant; (b) lack of sufficient quantity of the proper lubricant.

Many users believe in ball or roller bearings but have hesitated to put them into service, because of insufficient information, and because the motor builder does not urge their use and who, when asked for a quotation, makes the price almost prohibitively high. This class of user in general is merely waiting for the first class to say more about their experiences and for the motor builders to come out with a definite recommendation for the roller or ball bearing.

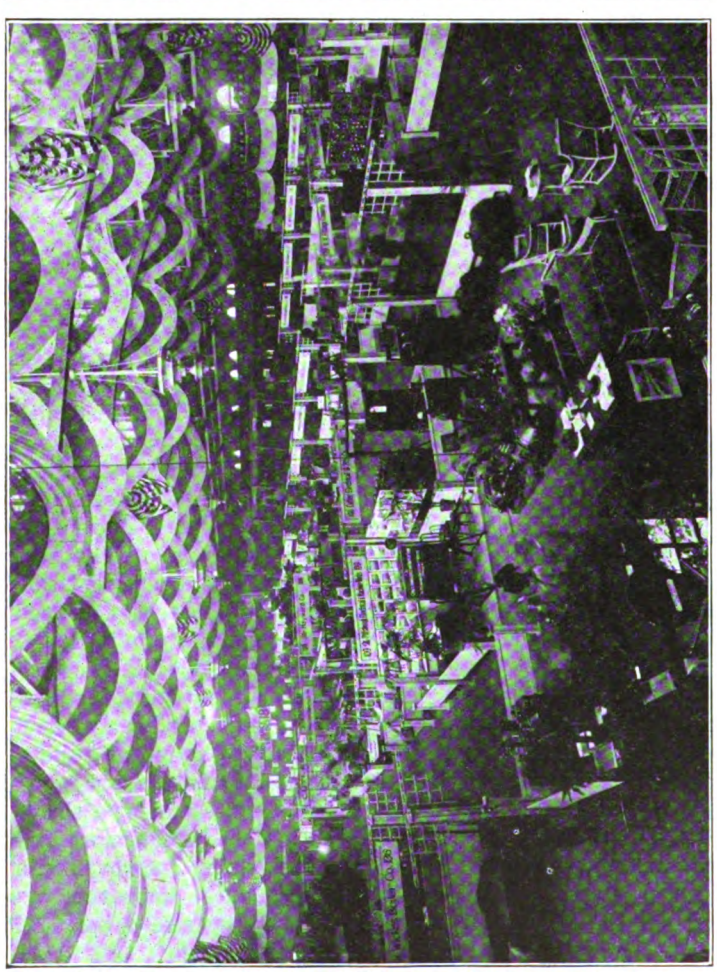
A third relatively small class do not believe in ball or roller bearings, primarily because they feel that the sleeve bearing, as now in general use, is satisfactory and meets the needs of their particular industry. As a whole, this class is using motors on relatively easy work or else does not know the real causes of its motor failures.

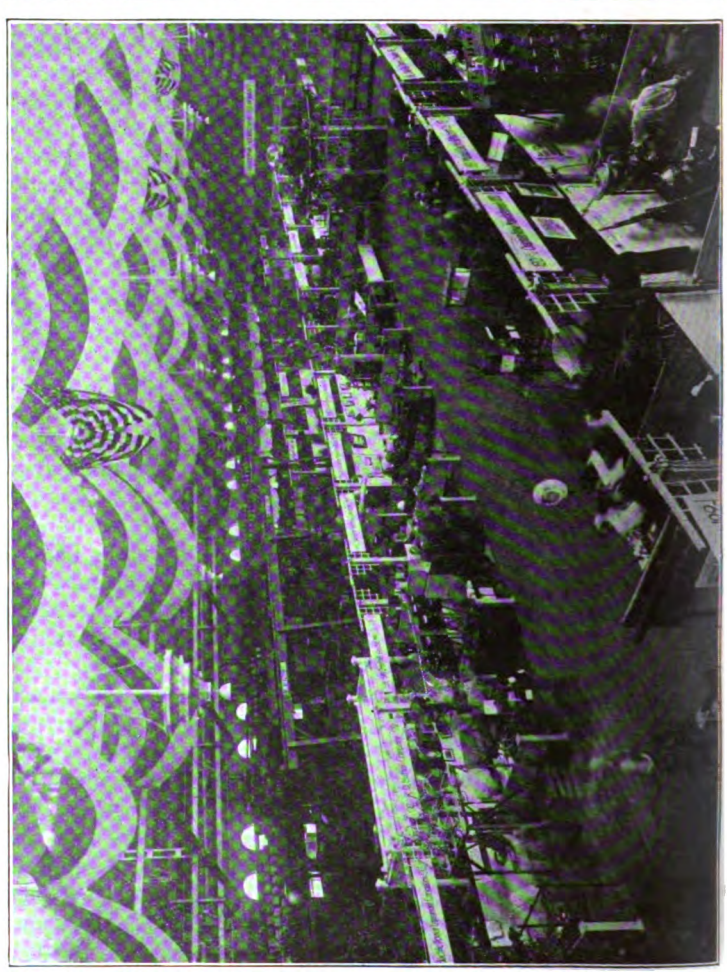
Among the motor builders we have three classes: (1) Those who have used ball bearings extensively. These builders usually report good results, and where a standardized method of mounting has been worked out do not quote excessively high prices for motors equipped with ball bearings when compared with their prices for sleeve bearing motors. (2) This class of motor builders includes those who believe that ball or roller bearings can be successfully applied, and are entirely willing to furnish motors equipped with these bearings, provided the motor user will pay the bill. The bill is high because no standardized method of mounting has been worked out. (3) We have the motor builder who believes that motors are good enough with the present type sleeve bearing, and who furthermore believes that if bearing improvements are necessary, such improvements can be made in the sleeve bearing.

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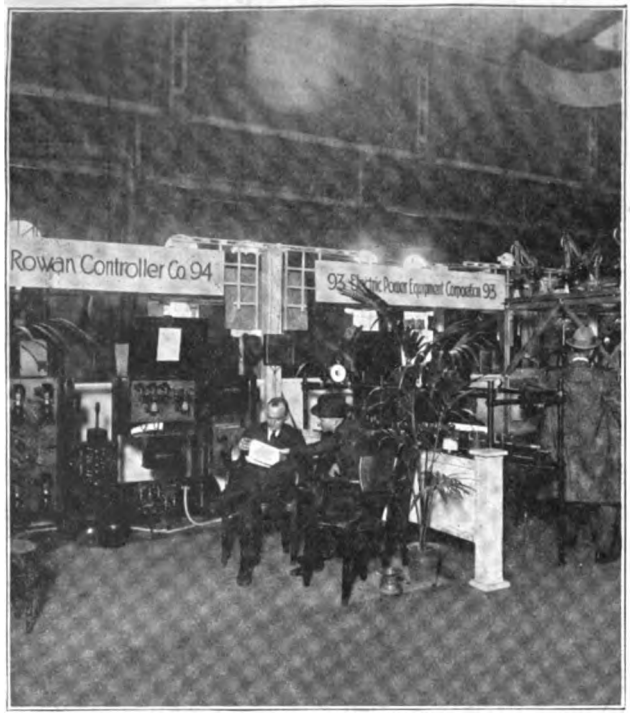


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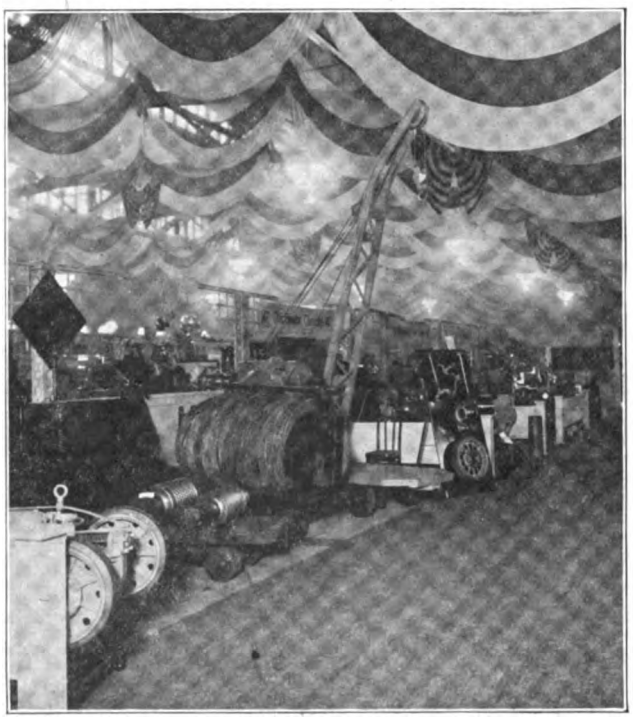
The Steel Mill Equipment Display

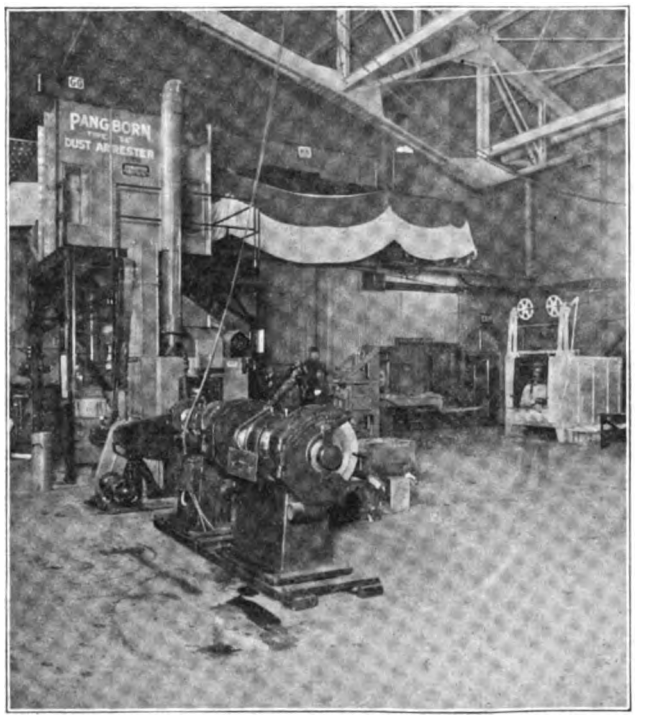
At Buffalo (N.Y.) Convention of Association of Iron and Steel Electrical Engineers

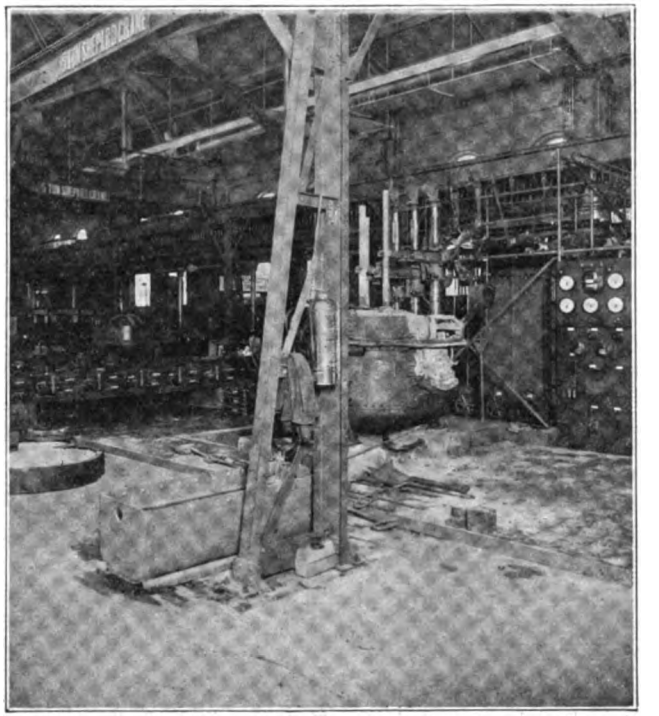
THE million-dollar exposition of steel mill equipment at Buffalo, N. Y., September 24 to 28, is shown from four angles on the opposite page. Below, in the lower center and lower right photographs, are shown two sections of the electrified foundry which was in operation during the convention. Molding, melting, pouring, cleaning, grinding and handling operations were demonstrated. A wide variety of equipment used in the iron and steel industry was on exhibition.











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His arguments against ball bearings include the argument of excessive cost of changing existing designs, with the cost and difficulty of doing the accurate machine work necessary in mounting the ball or roller bearings.

With the builders of bearings the ball bearing has been standardized internationally. This standardization includes three general weights of bearings, the light, medium and heavy. Each of these three general classifications includes many varieties. This standardization does not include the size of ball or shape of race, but the outside diameter of the outer race and the inside diameter of the inner race; in other words, the international standards make the mounting dimensions of ball bearings entirely interchangeable from one manufacturer to another.

Roller bearings of the large diameter, short length, solid type have been somewhat standardized along the same line. There are several lines of roller bearings on the market which are interchangeable with the medium series of ball bearings. Ball or roller bearings properly mounted are good or bad, depending upon the accuracy of the grinding. The use of ball and roller bearings is constantly increasing, consequently the manufacturing facilities have been constantly increasing so that the cost of the finished bearing has been and should continue to gradually decrease.

Roller bearings of small diameter and great length do not line up with the ball bearings as well as the roller bearing of large diameter and short length. Owing to the marked difference between this type of bearing and the ball bearing, it will very likely be found necessary to make a separate standardization. Within any series of bearings there lies a wide choice of design ranging from the shallow flat race with a small number of large diameter balls to the very deep race with a large number of small diameter balls. These various designs have their particular points of advantage which should be taken into consideration by the user as well as the builder of motors with the liberal co-operation of the bearing engineer.

The minutes of the joint meeting of the Bearing Committee, A. I. & S. E. E. and the Power Club contain the following recommendations:

1. It is desirable to standardize bearings as quickly as possible so that motor users may install roller or ball bearings in existing motors and use sizes which will line up with standards to be used by motor builders in the future.

2. It was considered desirable and practical to standardize on ball-bearing sizes that will be interchangeable with roller-bearing sizes so far as outside and inside diameter is concerned. Roller bearings in this discussion being limited to the solid roller type, it was pointed out that while a roller bearing and ball bearing of the same inside and outside dimensions would be interchangeable from a mounting standpoint, the roller bearing would almost invariably be capable of carrying a somewhat heavier load.

3. It was considered advisable to adopt the standard ball-bearing sizes of the 300 series, and that the roller bearings be made to conform to these sizes so far as inside and outside dimensions are concerned.

4. That the number of sizes standardized upon for motors be limited to the smallest number practical so as to reduce the number of spare bearings necessary to stock for protection against breakdowns.

5. That no attempt be made to standardize on any particular size of bearing for a given frame size of motor of any given horsepower rating or speed but that the selection be left in the hands of the designing engineers.

Motor-Operated Centrifugal Pumps

By B. A. CORNWELL,

Electrical Engineer, Carnegie Steel Company, Youngstown, Ohio.

IN THE steel industry, one of the most important factors in maintaining and increasing production is the efficiency and the reliability of the water supply system, which we feel should be electrically driven. Centrifugal pumps are especially suited for handling large quantities of water quickly and in many plants this type of pump has been adopted for supplying water under low heads for blast furnaces, condensers, cooling water systems, etc. The velocity imparted to the water by the impeller determines the head and the following general laws govern the action of all centrifugal pumps: (1) The head varies as the square of the speed; (2) the quantity of water pumped varies directly as the speed; (3) the power required to drive the pump varies as the cube of the speed.

A centrifugal pump is the simplest type of pump, hence the first cost and maintenance is less than for other types. This type of pump does not require a licensed engineer, neither does it have steam line losses while idle as with a steam pump. There is no reciprocating motion—consequently the discharge is free from pulsations, avoiding the necessity of air chambers. The entire absence of valves and plungers allows the pump to pass solids as found in sewage which would interfere with the successful operation of a pump dependent upon valves. With electrically-driven centrifugal pumps there is the possibility of remote control.

Due to the construction and the characteristics of this type of pump, the starting requirements are not heavy, as the starting torque rarely ever exceeds 30 per cent of the full load torque. With a centrifugal pump, decreasing the head pumped against will increase the load on the motor. The design of this type of pump is such that it will raise considerably more than 4/3 the amount of water at a 30-ft. head than it would at 40-ft. head, with the result that the motor is greatly overloaded. In this respect, the centrifugal pump is exactly opposite to the plunger or reciprocating pump which being positive in its action, increases its load with the increase of head and *vice versa*.

With the discharge valve closed the efficiency is zero, since no useful work is being done. The horsepower required under this condition is consumed in friction and dissipates itself as heat with the result that an electrically driven pump of this type cannot be operated with its discharge valve closed for more than 15 or 20 min. without overheating.

Interesting data were recently obtained from tests made on a large centrifugal pump in a steel mill. In order to make a comparison of the cost of the electric power consumed by this 1,000-hp., motor-driven pump with a steam turbine driving this same pump on the same service, we must first get the operating cost per kw.-hr. at the motor and the cost per pound of steam at the supposed turbine. The average cost per kw.-hr.

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for the electric power in the plant where this pump is operating is $0.00355—the generating station being blast furnace gas engines.

Allowing a 2 per cent loss in the 6,600-volt line to the motor and taking the station cost of power at $0.00355 per kw.-hr., gives an average cost of power at the motor of $0.0036 per kw.-hr. From the results of tests this pump has its maximum efficiency at 725 r.p.m. when delivering water at the rate of 30,000,000 gal. per day against a head of 163 ft. Under these conditions the input to the motor was 828 kw. The cost per hour equals 828 × $0.0036 equals $2.98 for electric power when delivering water at rate of 1,250,000 gal. per hr., or the cost of pumping 1,000 gal. of water per hr. will be 2.98÷1250 which equals $0.00238.

The operating cost for steam power delivered to a supposed turbine driving this same pump on the same service is, as closely as may be estimated, $0.00288. In case the electric power is produced by a steam turbo-generator, the operating cost of the electric power to the motor driven pump will be slightly higher. In case lower pressure saturated steam is used to operate the turbine driven pump, or if a good vacuum cannot be maintained the operating cost of the steam driven pump will increase greatly. The operating cost of the direct acting steam pump varies from 3½ to as high as 15 times that of the motor driven centrifugal pump.

The comparative initial costs of the 1,000-hp. electric motor and the turbine driven installations including starters or condensers and auxiliaries, but exclusive of buildings, wiring or piping, which would vary greatly depending upon local conditions, is as follows:

Induction motor driving pumping unit	$15,400
Synchronous motor driving pumping unit	15,800
Steam turbine driving pumping unit	38,000

However, in this comparison, the motor driving the motor driven pumping unit should be charged with its part of the power station costs exclusive of boilers in case turbo-generators are used, or in case power is produced by gas engine driven generators, the motor driven unit should be charged with its proportional part of the power station costs and the turbine driven pump with its part of the boiler house cost. This would work out about as follows:

A 15,000 kw. turbine generating station exclusive of boiler house would cost approximately $53 per kw. of capacity.

A 21,000 kw. gas engine driven generating station would cost approximately $190 per kw. of capacity.

A boiler house for 10,000 boiler hp. output would cost approximately $2,600 per 1,000 lbs. of steam per hr. capacity.

All of the above figures have been estimated and do not include any spare equipment.

Investigations have been made showing a comparison between a totally electrically driven steel mill with modern equipment and a steam driven plant using the same conditions of fuel costs, etc., which show that the electrically driven plant has the advantage of from $2 to $2.50 per ton of material shipped when compared to the totally steam driven plant.

With centrifugal pumps there is a definite relationship between the capacity and the head against which the pump has to operate. It is a velocity pump and in many instances, even those who have used a pump of this type, do not fully appreciate how sensitive it is to speed changes.

Within the past few years there has been a decided tendency toward higher speeds in the design of centrifugal pumps. High speed is desired because it reduces the number of stages required for a given capacity and consequently the first cost is less; furthermore higher speeds on pumps give higher efficiencies.

In most direct current installations a shunt wound motor is used. When the equipment is to work under a varying head and capacity it is possible in many instances to obtain the proper speed variation by means of the field rheostat—an increase of about 15 per cent can be obtained in this manner. The pump must be designed so that the desired capacity and maximum head are obtained at the maximum motor speed, otherwise there would be a possibility of overloading the motor to the danger point.

The great majority of installations make use of an alternating-current motor. Where constant speed is desired and where the inrush of current at starting is not detrimental, a squirrel cage motor may be used. In most steel plants the heavy starting current is not desired and in such cases a wound rotor or slip ring motor is used. The choice of the type of motor depends upon the starting conditions and the capacity of the generating station supplying power.

Synchronous motors are used in many instances where the power factor is low. With the discharge valve closed, the pump primed, and operating at normal speed, the motor must develop a pull-in torque of approximately 40 to 50 per cent of full load torque in order that it may come up to synchronism. The chief advantages of using synchronous motors for driving centrifugal pumps is in the power factor correction. The pumping load is ideal for this, inasmuch as the pump load is usually steady and constant.

In some installations using synchronous motors for driving centrifugal pumps a magnetic clutch is used between the motor and the pump. When the pump is not needed the clutch may be disengaged and the motor allowed to run idle as a synchronous condenser to raise the power factor of the system. From the standpoint of safety, automatic control should be used in starting up all synchronous motors driving centrifugal pumps.

There is another type of synchronous motor now on the market which is called a "super-synchronous" motor with a revolving stator and brake mechanism. This motor is capable of exerting a starting and accelerating effort in excess of the rated full running torque of the motor. By taking advantage of this characteristic, heavy starting torque is secured mechanically by the addition of this brake mechanism. This type of motor is well suited for driving fans and centrifugal pumps starting under load, and could be used to advantage in many other steel mill applications.

Where steam pumping equipments have been entirely replaced by electrically-driven outfits the efficiency and the operating costs have been greatly improved. However, in connection with electrically driven pumping stations, steam driven pumps in many cases are necessary to insure a continuous supply of water in case of failure of the electric power. It is generally conceded, that where electric power is available, there is no satisfactory comparison between the electric motor and gas or steam engine drive for centrifugal pumps. The first cost, maintenance and attendance are considerably less, the simplicity and the reliability much superior and the power cost ranges from 25 to 50 per cent less, as has been demonstrated from actual tests.

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System in Electrical Division Work

By P. T. VANDERWAART

Electrical Engineer, The New Jersey Zinc Co., Palmerton, Pa.

IN THIS paper the author presented a discussion of present practice in handling routine engineering work, such as the preparation of specifications, estimates, plans, and lists of materials for construction, and the recording of location, inter-relation and duty of apparatus. The following abstract gives the main points taken up with comments on practice and experience by the author.

Supply House Material should be used whenever possible, even to the extent of sacrificing a minor feature in design. The layout engineer must have before him an up-to-date list of the standard supplies in stock. This list gives a complete specification of each item, the standard package quantity, the minimum stock quantity tolerated, the unit cost plus loading, and space for dates and remarks. The original forms and entries, excepting unit costs and dates, are made on tracing cloth and white prints are issued to interested parties, such as the purchasing department, supply house, engineering division and foremen of construction and operation. An estimator is particularly interested in the unit costs, which he keeps up to date by pencil notations and revisions on his set of white prints.

A considerable amount of detail work on estimates and plans can be saved by the adoption of *Construction Standards*. These standards are the logical place to list the required sizes of screws or bolts for different fittings. For example, a standard on "conduit clamps" gives the proper assembly of clamp, screw, and expansion shield for each size of conduit.

Liberal reference is made to standards on specifications and estimates. On the *Estimate Sheet*, for instance, the requisite number of lighting outlets 1-X-343, is set down under material, the unit labor and material prices plus loading copied from the book of standards, and the totals carried out. Materials not included in the unit cost of the standard are similarly taken from the supply house material sheet.

The *Lists of Material* for drawings are typed and filed separately under construction account numbers, with proper cross references. Sufficient copies are made for purchasing, supplies, construction and engineering files.

The *Job Progress Sheet* prevents the overlooking of any part of any job. As soon as it is decided to go ahead with a job, the necessary items of work and apparatus to be purchased are listed. Promised dates for completion can be entered under remarks. Actual date of completion is noted in proper column. The sheet shown is a check suitable only for the drafting column. The general engineer on the job will keep a more complete check on delivery of materials and construction progress.

Systematic load records are every bit as important as apparatus records. *Feeder Load Records* are kept in a loose leaf file. Each sheet shows for a particular feeder the connected load, kw-hr, and average and maximum amperes for stated time periods. Space is provided for recording voltage observations and power factor and load factor calculations. Fifty-two entries can be made on each page. If the time periods are weeks, the complete load history for a year is recorded on a single page in convenient form for reference.

The records are posted from weekly reports of watt-hour meter readings and *graphic charts*. Each feeder has a watt-hour meter and a graphic ammeter, and each station bus has a graphic voltmeter. The back of each chart is stamped to provide a place for the meter man to note down the feeder name and number, time started and time stopped, respective watt-hour readings, the ammeter constant, and the watt-hour meter constant.

These records include total power house and substation loads as well as loads in the several feeders from the substations. Accurate diversity factors are therefore easily and quickly calculated.

Systematic work is nowhere more important than in tests on operating apparatus. For one reason or another information on power requirements or production data is desired from time to time by different individuals, and each will usually emphasize the feature in which he is particularly interested to the exclusion of other desirable or even necessary data to make a complete report.

Many plants are making motor load surveys which record nothing more than the power input to the motor, with possibly some comments on the load cycle as shown on a graphic chart. Correlative information on the driven machine and its output should be taken.

PAGE 10 REVISION

SUPPLY HOUSE MATERIAL	STD PKG.	MIN. STOCK QUANT.	UNIT COST +LOAD	DATE	REMARKS
Rim. 1-1/2" x 9" Std. Lacquer. Wood	500	50			
" Pierce, #93A. Mat Galv.	100	10			
" Leg without thimble Mat Galv. 1/4"x5-1/2" Stud B.Type Cat.9005	50	25			
Plate,Double Wings Lift cover. Hubbell #5990	10	10			
Plug. Alex Plural Socket. W. E. List #25		5			
Plug. Swivel Attachment Benjamin #903	10	10			
Plug. asso. Crampes. Attachment. Hubbell #5619	10	10			
Plug. Cap. Crampes. Attachment. Hubbell #5687	50	10			
Receptacle. Pajaie Fielding Pajaie #50726	10	10			
Receptacle. Plug. Flush Hubbell #5579	10	10			
Reflector. Ivanhoe. RFD-60	50	10			
" " RFD-75	40	10			
" " RFD-100	25	5			
" " RFD-200	5	10			
Salt. Yeagers Soldering - 1/2 lb. Bottles		5 lbs.			
Screws. Mach. Fillister Head Mat Galv. #14-20 x 1/2"	500	50			
" " " " " #12-16 x 3/4"	500	50			
" Lag. Peiter Drive Mat Galv. 1/2" x 2-1/2"	100	50			
" Mach. R. H. Mat Galv. #12 x 1-1/4"	500	100			
" " " " " #14 x 1-1/4"	500	100			
" " " " " #18 x 1-1/2"	100	50			
" " " " " #24 x 2"	50	25			
" " " " " #30 x 2"	50	25			

Lists of standard supplies are made on these forms which show at a glance the minimum quantity carried in stock, standard package quantity, and so on.

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In and Around the Steel Plant

Electric Furnace Phenomena

By EDWARD T. MOORE

Electrical Engineer, Halcomb Steel Co., Syracuse, N. Y., and Consulting Engineer, Crucible Steel Co. of America, New York.

INVESTIGATIONS were started in July, 1922, but because of the large amount of data secured it was impossible to properly analyze it and prepare a paper for the 1922 convention. This work has since been done and was presented as the Electric Furnace Committee's 1923 report.

The tests were conducted at the works of the Halcomb Steel Company, Syracuse, N. Y., on one of the company's six-ton Heroult furnaces. This furnace is one of the counterweight type and has connected to it three 500-kva. single-phase, self-cooled, core-type transformers.

Results obtained in the tests indicated that the maximum difference between phases was 340 kw., or 21 per cent of the connected load.

In the short-circuit test the maximum short-circuit value was found to be 3.66 times normal. This checks remarkably closely with previous tests where the highest value was 3.61 times normal.

From the readings taken the following average power factors were secured: melting period, 90 per cent; refining period, 88 per cent; for entire heat, 89 per cent. Therefore, an electric furnace such as the one under test is a very desirable load from a power factor standpoint and will always operate at a higher power factor than induction motors.

Other results and observations are: that at heavy loads the power factor goes up; that there is no large disturbance of power services on the furnace circuit beyond a momentary swing in voltage when the furnace load comes on. These voltage variations were of only average magnitude—not over 4 per cent. The load taken by the furnace and the amount of reactance in the circuit determine surges or fluctuations. Short circuits, such as occur in a furnace when charging cold scrap, do not generally take place across all phases at once, although at times all phases may be shortened. Some unbalancing occurs but it is not sufficient to cause the slightest trouble on a power system of adequate capacity.

A relatively high speed of electrode travel was found desirable and resulted in re-establishing the arc, after it had been extinguished by the fusing of a portion of the scrap, very much sooner than with slower electrode travel.

When integrating watthour meters are connected to the primary side of the transformers supplying the furnaces, these meters are accurate within commercial limits.

When meters are connected to the secondary side there is no doubt that serious errors in registration would result, due to presence of direct current caused by rectification in arc.

Electric Transportation

By F. O. SCHNURE

Electrical Engineer, Bethlehem Steel Co., Sparrows Point, Md.

YARD haulage and transportation within a steel plant, probably represents the largest variety, if not the most severe work of any industrial haulage. Yard electrification as a factor in bringing lower haulage costs, should be of prime interest to the steel industry. Present steam practice, and electric in other fields, would indicate that two sizes of locomotives are required for steel plant service and that these should average about 40 and 80 tons per unit. This classification makes it very simple to standardize on the 40-ton unit, the control on which should be so arranged that two such units could be operated in multiple by one man on the heavier service.

In a plant employing twenty-five steam locomotives, ranging from 50 to 75 tons capacity, it is altogether likely that twenty electrical units would perform the same work. Hostler service, not required on the electric unit, and boiler repairs usually keep several steam units out of service every day. The repairs on an electric locomotive comparable to boiler repairs would be the practically negligible time to change a motor. The control on the electric locomotive should be electro-pneumatic to avoid low voltage troubles and should be arranged to be operated from opposite sides of the cab.

The third rail lends itself more readily to steel plant yard electrification than an overhead trolley, because it does not interfere with the work of locomotive cranes, and it is better able to handle the heavy operation at low voltage. There are two kinds of third rail systems, one the top contact and the other the bottom contact system. For yard work where switchmen and plant employes may not be denied free and safe passage over all portions of the yard, the bottom contact is preferable.

Electrification of the Foundry

By LEONARD W. EGAN

Special Engineer, Ohio Steel Foundry Company, Lima, Ohio

The discussion of the various types of electrical apparatus used in the foundry was divided into seven or eight general subjects: (1) Electric molding machines. (2) Sand handling systems. (3) Electric furnaces. (4) Cranes. (5) Purchased power. (6) Electric welding. (7) Safety. (8) Air and electric hoists.

Adaption of mechanical molding by use of molding machines permits the use of a cruder grade of labor in about 80 per cent of the work of making molds.

The two outstanding features in the electrification of machine molding, which have been brought out in the last few years, are (1) the roll-over jolt Pattern Draw Machine with electrically operated pattern draw and roll-over, equipped with electrically operated runout car, and (2) the Sand Slinger.

The Sand Slinger is a molding machine which employs a radically different principle in its operation than that of any other type in existing practice. The sand is pitched or thrown into the mold at high velocity, which rams or packs it around the pattern.

A complete, well-built and motor-operated sand handling and conditioning system is needed in every foundry of any importance. The work entails a number of operations and there is a number of ways in which this work can be done, which will vary in the general arrangement of each installation.

The electric annealing and heat-treating furnace has had a considerable development in the past five or six years, especially the treating furnace. It has a high degree of flexibility and where quantity production of a uniform type is possible, it offers unlimited possibilities in heat treatment.

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In the melting of non-ferrous metals such as copper, bronze, brass, aluminum, zinc and the multitude of special metals and alloys, including cupro-nickel metals, bearing metals, white metals, etc., the electric furnace is finding a broader application every day.

There are four principal types of furnaces in use in this branch of melting: The open arc, the muffled or smothered arc, the resistance and the induction furnace

The electrically-heated core oven is coming into more general use every day, not only because of the vast improvement in the quality of the cores, but where the cores are irregular in shape, and of the smaller variety, baking can be done cheaper and faster.

The process of electric welding is being used more and more in the foundry for welding castings. Both the metallic electrode and the graphite electrode processes are used, depending on the requirements and nature of the work.

Air cylinder hoists are used to a large extent in the foundry industry, chiefly in conjunction with hand-moved jib cranes. Trouble with the electric hoist in the past has been due to inability of the hoist to withstand the abuse received. With the advent of a more rugged type, the electric hoist will be more likely to supplant the air hoist which is now in general use.

Blast Furnace Skip Hoists

By A. C. CUMMINS

Electrical Superintendent, Carnegie Steel Co., Duquesne, Pa.

and

A. R. LEAVITT

Electrical Engineering Dept., Carnegie Steel Co., Duquesne, Pa.

IN MAKING a selection of the correct type of equipment to be used for a given hoisting problem, the electrical engineer must carefully weigh the advantageous features of each. This paper called attention to the principal features claimed for each of the four types of electrical apparatus for single-bucket blast furnace skip hoists, enumerating the claims made for each variety of equipment and also their limitations, and presented data secured while checking over the actual performance of a number of hoists to corroborate the various points of superiority which each type is said to possess. The four types of drive discussed were: (1) Single motor, direct current; (2) double motor direct current; (3) single motor alternating current; (4) Ward-Leonard or variable-voltage drive using either alternating or direct current.

A part of this paper which covers a discussion of the effect of various types of inclines upon handling of material is given in the department "Handling Materials" which begins in this issue on page 513.

Main Points in the Discussion at Buffalo Convention

WHILE most of the papers presented dealt with practical operating conditions rather than theoretical or untried practice, the discussion brought up important points on which experience agreed or differed under the same or other conditions. These practical points and comments by the various speakers who discussed the papers are given briefly in what follows.

In connection with his report, F. W. Cramer, Chairman of Standardization Committee, urged that the directors of the association request the management of the large steel plants to appoint an official representative to co-operate with the standardization committee and that this committee should co-operate with the American Engineering Standards Committee. As a starting point for standardization it was suggested that holes for the holding bolts of motors be spaced in a uniform manner. Contacts for control boards were pointed out as another item that should be standardized.

In referring to the report on electrical developments, Mr. Kennedy reminded the chairman that a 5,000-hp. electric reversing mill drive was installed in 1916 at the Mark plant of the Steel & Tube Company of America, one year earlier than mentioned in the report.

As part of the report of the special bearing committee, of which D. M. Petty was chairman, fifteen standard sizes of ball and roller bearings were tentatively proposed. These were sizes 305, 306, 307, 308, 309, 310, 311, 312, 314, 315, 316, 317, 318, 320 and 322. These are for general purpose motors of 1-hp. to 100-hp. In the discussion on this subject it was pointed out that as roller bearings will carry heavier loads, except at higher speeds, than ball bearings of the same dimensions, this greatly increases the possible number of applications. Further discussion with members and with the Electric Power Club was suggested before any sizes are finally declared standard, in order to avoid the possibility of error.

Mr. Hipple of the Electric Power Club warned the members not to rush the adoption of ball and roller bearings, as they are not altogether out of the experimental stage and also because sleeve type bearings will probably be developed which will not have the troubles of the present sleeve bearings; namely, slinging oil and allowing the entrance of grit and dirt into the bearings. However, the consensus of opinion of the operators attending this session was that roller and ball bearings have advantages that will increase their use. A. C. Cummins, electrical engineer, Duquesne Works, Carnegie Steel Company, stated that burnouts on a number of motors were much less frequent after he had substituted ball bearings for sleeve bearings. In this connection he mentioned a trouble which he had experienced with ball bearings. This was that the balls were damaged by current when a motor developed an accidental ground. The balls of these bearings often were so badly overheated that their life was very short after this trouble. As a result the cost of replacing bearings sometimes overbalanced the saving in armature repairs. He mentioned, however, that there are ways in which this trouble can be removed. He is, for instance, trying out a brush which is connected to the motor frame at one end and bears on the shaft at the other end, the object being to shut off the current before it reaches and damages the bearing.

In the discussion on motor-operated centrifugal pumps, several speakers agreed with the author of the paper that electrical drives are more economical than steam. An important advantage of the electric drive is the possibility of making it semi-automatic, thus eliminating the costly attendance required by steam drives. (*Continued on page 515.*)

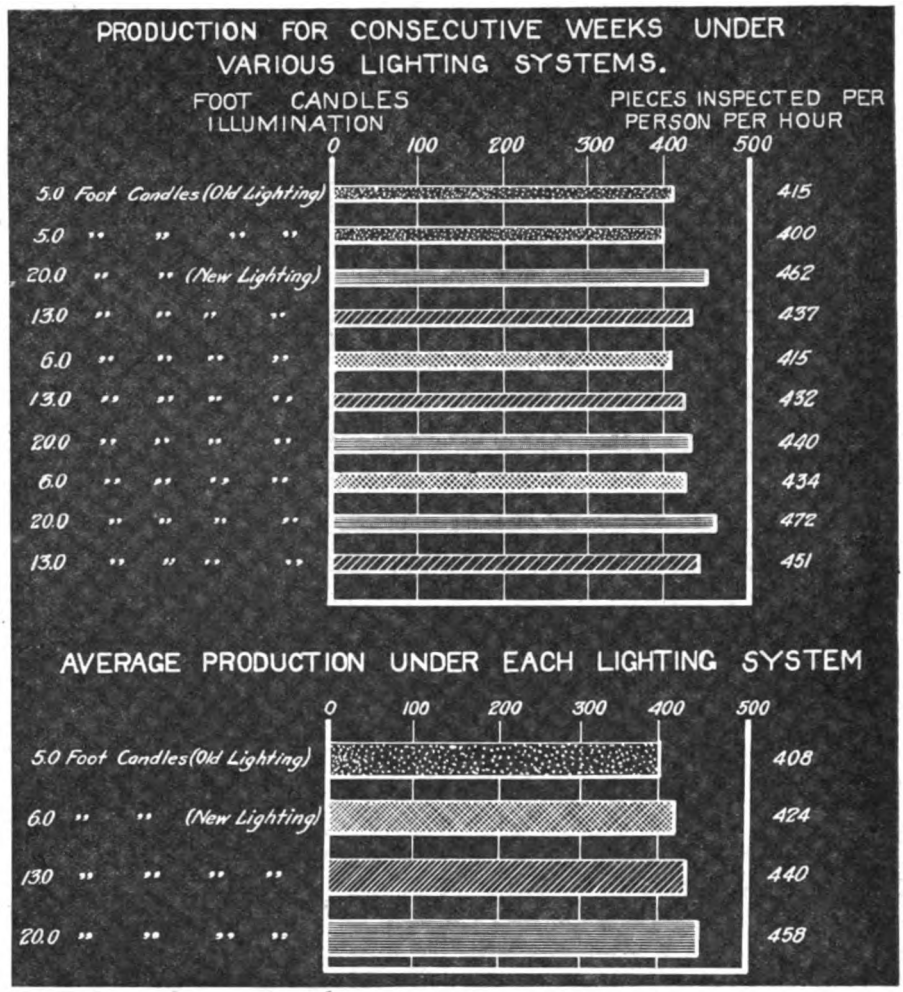
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THE RESULTS of the tests described in this article are of particular interest to industrial plant men, for they indicate in a practical way what can be accomplished by the use of higher lighting intensities where speed is an element in a manufacturing operation.

Results of Some Tests on

Relation of Lighting to Production

Showing How a 12.5 Per Cent Increase in Production Resulted from Increasing the Lighting Intensity



BY D. P. HESS

Manager, Columbus Plant, The Timken Roller Bearing Company

and

WARD HARRISON

Illuminating Engineer, National Lamp Works of General Electric Company

THE information that follows relates to a test that was recently conducted at the Columbus (Ohio) Plant of the Timken Roller Bearing Company to establish what relationship, if any, exists between illumination and production in a factory that manufactures roller bearings. This information was presented before the Illuminating Engineering Society at its convention at Lake George, N. Y., September 24 to 28, 1923.

About fifteen per cent of all works employes of the Columbus plant are inspectors and the section chosen for the test was known as the *Green Inspection Department*. The nature of the work in this department consists of inspecting the material in the green, that is, just as it is turned out by the automatic screw machines and before heat treating. The material inspected as illustrated in Fig. 8 consists of various sizes of cups, cones and threaded cones, which are separate parts of a roller bearing.

The work is carried on in three stages: The first group of inspectors guage the material for diameter and depth; the second group inspect for defects such as chatter, tool marks, ingot breaks, thin ribs, and bad chamfer; and the third group for imperfections in the thread on the inside of the cones, bad mill, bad chamfer, and inadequate burnishing. Some of the work such as the inspection of threaded cones, ingot breaks and chatter marks requires close visual inspection, while in some of the gauging, which is done by means of indicating and limit gauges, as illustrated in Figs. 9 and 10, relatively little is required of the eyes.

The personnel of this department at the time the test was begun consisted of foreman, clerk and thirty-eight inspectors. This number varied each week, the average inspectors during the test being forty-four. Table I shows the weekly change in personnel of the department during the entire test.

The area occupied by the *Green Inspection Department* has dimensions of approximately 30x60 ft. and is located near one corner of a large one story building covering about 6 acres. (See Fig. 2.)

The lighting system in this department at the beginning of the test consisted of 6 outlets, 4 of which were equipped with 200-watt clear lamps, and 2 with 150-watt clear lamps. The 6 lamps were equipped with enameled steel reflectors and gave an average illumination of about 2 foot-candles. The distribution of light, however, due to wide and irregular spacing of the units, was uneven and caused bad shadows. Fig. 1 shows the lighting effect produced by this system.

The department is so located that it receives daylight from windows at a distance on one side and from skylights located in the saw-tooth roof construction. During the greater portion of the time throughout the first two weeks of the test, the above mentioned lighting system was used as a supplement to the natural daylight. The resulting average illumination in the test section for this period was approximately 5 foot-candles.

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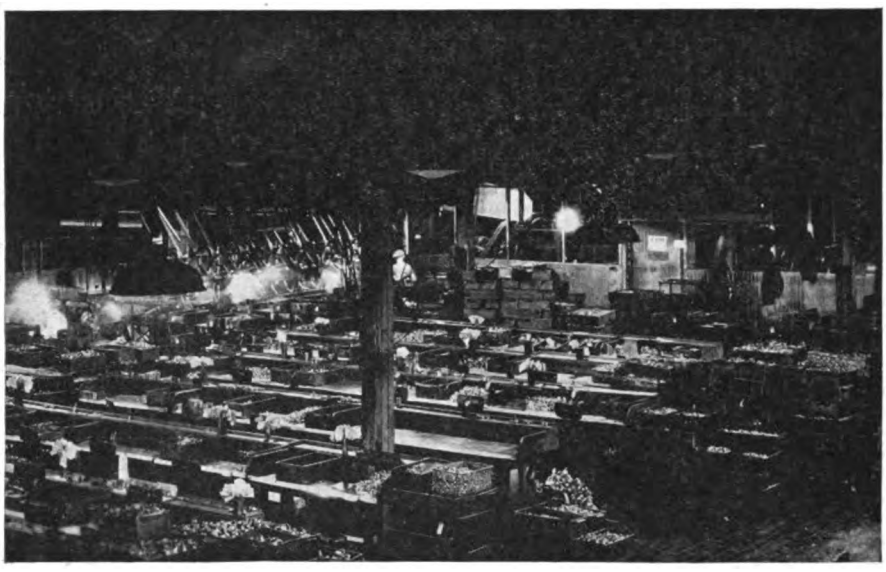


Fig. 1—Original lighting at the beginning of the tests showing uneven distribution and bad shadows.

The new lighting layout, Fig. 3, consisted of twenty-eight Glassteel diffusers located on 8 by 10 foot centers and mounted 12 ft. from the floor. This type of lighting unit (Fig. 4) has an enclosing globe that entirely surrounds the lamp, producing an even distribution of light with soft shadows, and a noticeable absence of objectionable specular reflection. The lighting effect obtained by the above mentioned system is shown in Fig. 5.

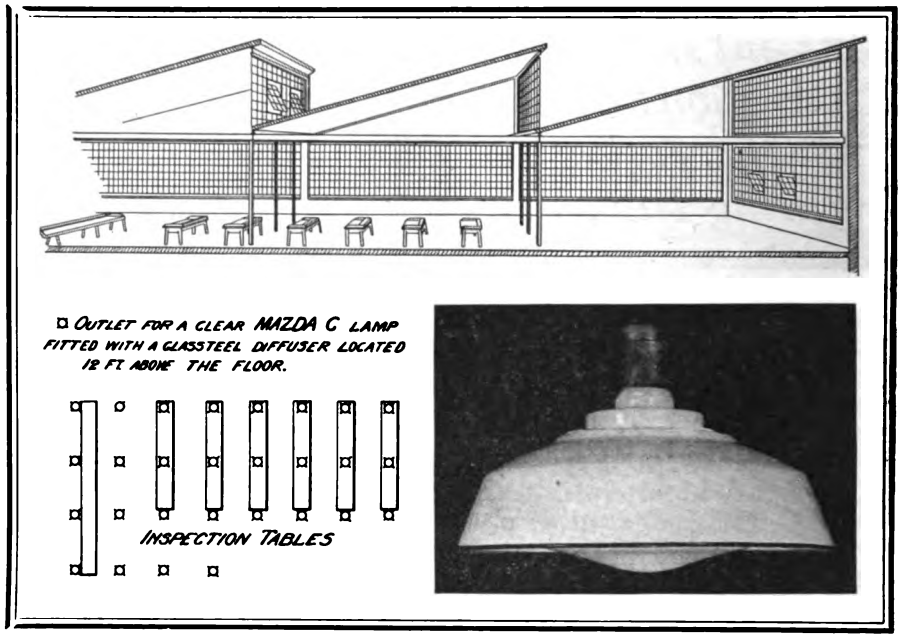
In an effort to maintain the levels of illumination under this system as uniform as possible, the skylights in the saw-tooth roof were blackened.

PROCEDURE IN THE TEST

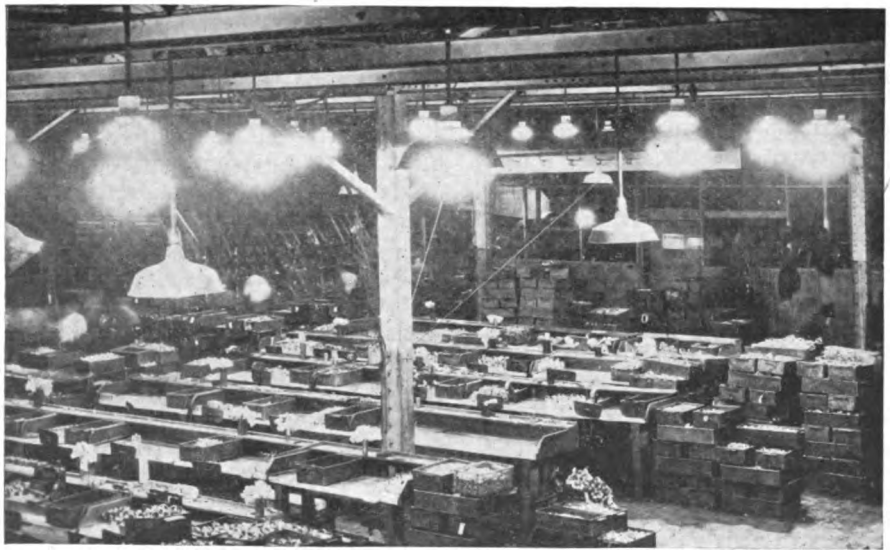
The test was planned to include investigations of the old system, a 6 foot-candle system, a 13 foot-candle system, and a 20 foot-candle system. The test weeks in each case were begun on a Thursday and ended on a Wednesday, continuing for a period of ten weeks. Due to the advancing season and much stronger daylight, it was found impossible to return to the original 5 foot-candle system obtained from the unobstructed skylight and 6 incandescent lamps. Table II gives the order of tests.

Records were available in the *Green Inspection Department* which showed the number of pieces inspected per day with the total number of actual inspection hours. Often, especially in the case of overtime, an inspector is called upon to do general work in the department, such as moving containers and cleaning up. In that event his time is not shown on the inspectors' records, but only on the time cards. If an experienced inspector is required to instruct a new worker, the experienced inspector's time does not appear in the inspection records. All employees in this department are paid on an hourly basis.

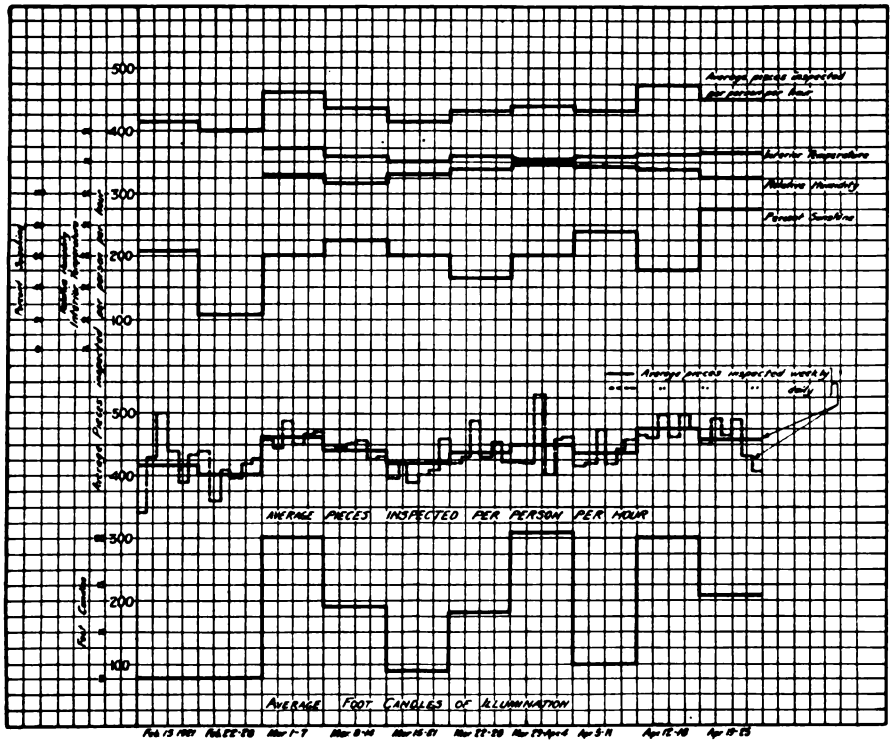
The question has often been raised as to whether atmospheric conditions materially affect the output of factory workers. In an effort to obtain data on this point wet and dry bulb thermometer readings were taken four times a day at the test area and from these the relative humidity calculated. The daily weather bureau record showing the per cent sunshine, exterior temperature, and amount of precipitation, was also tabulated.



Figs. 2, 3, 4 and 5—Sectional view of the department in which the illumination tests were conducted, together with lighting layout and reflectors used over inspection tables to secure increased illumination and lighting effect shown in the illustration below.



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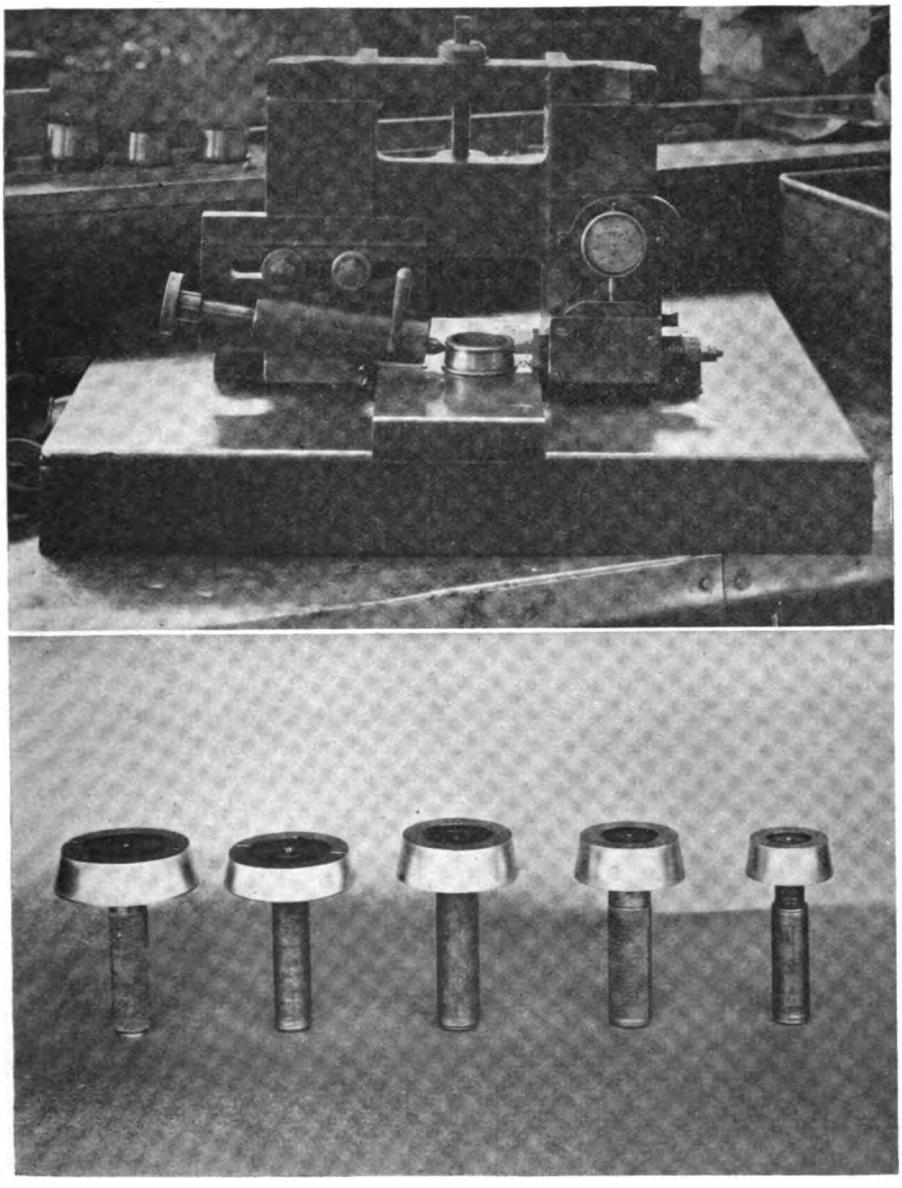


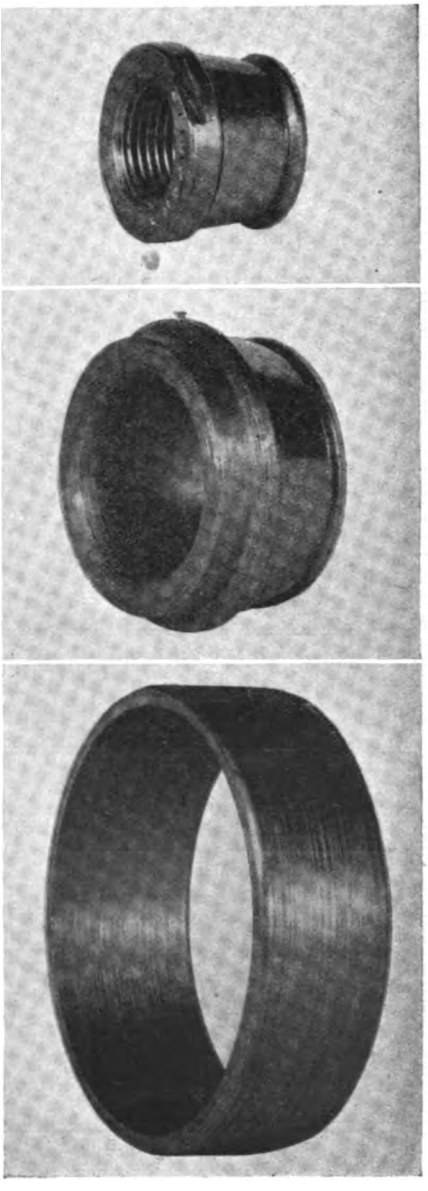
Figs. 6 and 7—Graphical presentation of production, temperature humidity and sunshine conditions during the illumination and production tests. Also daily rate of production during ten weeks. These curves show the average of the tests.

RESULTS OF THE TESTS

Table III and the curves of Fig. 6 show the per cent of sunshine, average weekly relative humidity and average weekly interior temperature. It will be noted that the tests were run at a season of the year when artificial heat was necessary and as a result both the interior temperature and the humidity were fairly constant. There was a considerable variation in per cent of sunshine for the several weeks but the variation

Fig. 8—Types of material inspected during the lighting tests.
Figs. 9 and 10—Indicating and limit gauges employed during the tests that do not require close visual inspection.





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Table I—Weekly Change in Inspectors in Department During Tests

	February		March				April			
	15-21	22-28	1-7	8-14	15-21	22-28	Mar. 29 Apr. 4	5-11	12-18	19-25
Total Inspectors	38	48	43	43	41	45	45	46	48	43
New Inspectors Hired	8	12	7	7	1	6	5	4	6	1
Inspectors Services Discontinued	2	12	7	3	2	5	3	4	6	6

Table II—Order of Lighting Tests Conducted During Ten Weeks

	February		March				April			
	15-21	22-28	1-7	8-14	15-21	22-28	Mar. 29 Apr. 4	5-11	12-18	19-25
Old Lighting—5 Foot-Candles	X	X								
New Lighting—6 Foot-Candles					X			X		
New Lighting—13 Foot-Candles				X		X				X
New Lighting—20 Foot-Candles			X				X		X	

Table III—Sunshine, Humidity and Temperature During the Tests

Week	Per Cent Sunshine	Relative Humidity	Interior Temperature
Feb. 15-21	63.0		
Feb. 22-28	22.0		
Mar. 1-7	61.0	66.4	74.8
Mar. 8-14	69.0	63.8	72.0
Mar. 15-21	58.0	66.5	71.0
Mar. 22-28	47.0	68.6	72.3
Mar. 29-Apr. 4	62.0	71.0	71.6
Apr. 5-11	76.0	70.3	72.0
Apr. 12-18	52.0	68.3	72.4
Apr. 19-25	90.0	65.5	72.7

Table IV—Number Pieces Inspected and Number Inspection Hours During Each Test Period

Intensity of Illumination	Total Pieces Inspected	Total Inspection Hours	Average Pieces Inspected per Person per Hour
5.0 F.C. (Old System)	684,164	1,644	415
5.0 "	581,709	1,449	400
20.0 (New System)	681,621	1,476	462
12.8 "	708,559	1,620	437
5.7 "	739,627	1,778	415
11.9 "	735,316	1,698	432
20.2 "	763,762	1,737	440
6.2 "	809,631	1,866	434
20.2 "	842,138	1,783	472
13.5 "	766,796	1,700	451

Table V—Percentage Increase in Production Under Each Lighting Intensity

Intensity of Illumination	Average Pieces Inspected per Person per Hour	Per Cent Increase
20.0 Foot-Candles	458	12.5
13.0 " "	440	8.0
6.0 " "	424	4.0
5.0 (Old)	408	0.0

apparently did not influence the production.

Table IV shows the total number of pieces inspected and the number of actual inspection hours for the department during each of the ten weeks of the test. The total number of pieces inspected was 7,313,323.

Table V shows the average of all weeks under the same lighting system with the percentage increase in production.

These results are also shown graphically on page 485 and in Figs. 7 and 11. Curves of Fig. 7 also show the daily rate of production for the entire period. The tests furnish apparently conclusive proof that for the class of work carried on in the *Green Inspection Department*, the production is materially affected by the character of illumination supplied. It will be noted that a well designed system of illumination, giving approximately 6 foot-candles with a minimum of glare and objectionable specular reflection, results in an increase of 4 per cent in production over that obtained under a faulty system which gave about the same average foot-candles. Likewise, an increase in illumination from 6 foot-candles to 13 foot-candles with a well designed system results in a further 4 per cent increase in production. Increasing the illumination from 13 foot-candles to 20 foot-candles results in an additional 4.5 per cent increase, or comparing the 20 foot-candle system with the one originally in use, a 12.5 per cent increase in production is found.

The current consumed with the 20 foot-candle system amounts to 8.4 kilowatts which at a rate of $0.03 per kilowatt hour results in a cost of $0.25 per hour for current to which should be added approximately $0.07 for lamp renewals and other charges, *(Continued on page 517)*

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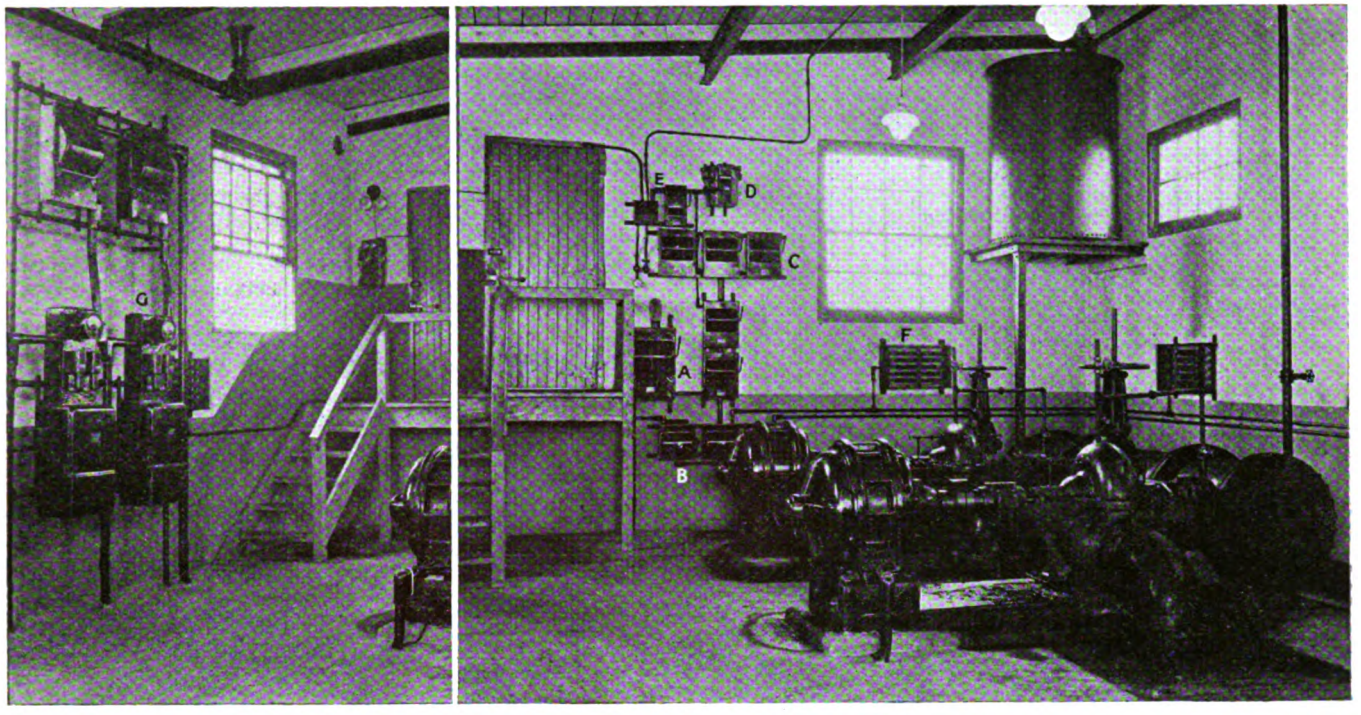


Fig. 1—Low-head pumps, motors and control equipment.
This shows the arrangement in a plant for pumping 11,000,000 gal. per day against a 50-ft. head. The motors are each rated at 75-hp., 550 volts, three-phase. At *A* is the main switch; at *B* the star-delta switches for controlling the three electric heaters such as shown at *F*, while at *C* are the disconnecting switches for the heaters. The compensators and their disconnecting switches are mounted on the pipe framework at *G*. At *D* is a 2-kw. lighting transformer feeding the lighting circuits through the distribution box at *E*.

Some Features of a

Pumping System For a Sulphite Pulp Mill

That Combines a Low-Head and a High-Head Plant Operating in Series

By H. E. STAFFORD
Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ontario.

IN THIS article operating details are given for a pumping system that supplies water to a 50-ton sulphite pulp mill operated by the Provincial Paper Mills, Ltd. This system consists of two separate plants, one a low-head plant and the other a high-head plant. The capacity of each plant is around 11,000,000 gal. per day, but since the plants are practically in series, the total capacity is the capacity of one plant. The low-head plant pumps the water from a lake into a concrete tank equipped with screens, as illustrated in Fig. 4. From this tank the water is pumped to the mill by the mill-service or high-head plant.

The low-head plant is at present equipped with two single-stage centrifugal pumps operating at a 50-ft. head and each delivering 4,000 gal. per minute or 5,760,000 gal. per 24 hours at 75 per cent efficiency. The pumps are equipped with foot valves placed in the pump well, which is fed from the lake through a 48-in. main. Each pump is driven by a 75-hp., 550-volt, three-phase, 1,160 r.p.m. induction motor, direct-connected to the pump. The maximum power required for each motor is about 80 hp. and since the power is practically constant, the average power is about the same. Fig. 1 illustrates the details of the installation. Power is fed to this station from the main substation, one-third of a mile distant, over a 250,000 circ. mil cable equipped at each end with expulsion-type lightning arresters. The main disconnecting switch is shown at *A* in Fig. 1. The compensators and disconnecting switches for each motor are mounted on pipe framework as shown at *G*, making them easily accessible for repairs. Each compensator is equipped with no-voltage and overload relays and an ammeter. Provision is made for the installation of two additional pumps to take care of future mill extensions.

Electric Heating Is Used in the Pumping Plant

The station is heated by nine electric heaters, shown at *F* in Fig. 1, of a total capacity of 37½ kw. Six of these heaters are rated 5 kw. each and three at 2½ kw. each. The heaters are made up of 110-volt space heaters, mounted on angle-iron supports and covered with mesh wire covers. The heaters are connected five in series on 550-volts, three phase, and may be connected in either star or delta, to give two heats with balanced currents in each phase. The fuses and disconnects for the heaters are shown at *C*, while the star-delta switches are shown at *B*, Fig. 1. The wiring diagram for the heating layout is shown in Fig. 3. The building is of concrete construction, 41 ft. long, 21 ft. wide and 14 ft. high, with two doors and eight 4-ft. by 4-ft. windows. The temperature goes as low as 45 deg. below zero in this climate, so that sufficient heating for this temperature had to be provided. In severe weather, 25 deg. to 45 deg. below zero, the full heat or delta connection is used,

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while for temperatures around freezing, the low-heat star connection is used. The heat requirements were figured from the formula:

$$\text{Watts}=5A+50a+VK.$$

where A=area in sq. ft. of all walls and ceiling, with area of windows deducted.
a=area of windows, sq. ft.
V=cubic feet of air space in building.
K=a constant depending on the outside temperature.

Values of K are: 1.5 for temperatures above 20 deg. below zero; 1.0 for temperatures between zero and 20 deg. below, and 0.5 for temperatures from zero to 10 deg. above zero.

EXAMPLE—Total area of walls and ceiling=1,148+588+861=2,597 sq. ft.

The total area of the windows—8×4×4=128 sq. ft.

Area of walls less windows=2,597—128=2,469 sq. ft.

Cu. ft. of air space=12,054 cu. ft.

K=1.5.

Total watts=(2,469×5)+(128×50)+(12,054×1.5)=36,831 watts or 36.8 kw.

The low-head station lighting consists of four 100-watt units equipped with eye diffusers, spaced on 10-ft. centers. These are supplied by the 2-kw., 550/110-volt transformer, *D*. The distribution panel is at *E*.

Water is delivered from the low-head station through a 30-in. main to the tank before mentioned, which is shown at *D* in Fig. 2. The water runs into a head box and over a screen, as the water for mill purposes has to be free from dirt. The layout of the tank, screen, head box and overflow is shown in Fig. 4, while the pump and motor installation is shown in Fig. 2. The station is equipped with two 120-ft.-head, single-stage pumps, with a capacity of 4,000 gal. per minute each or 5,760,000 gal. per 24 hours, at 74 per cent efficiency.

Each pump is driven by a 175-hp., 550-volt, three-phase, 1,160-r.p.m. induction motor direct-connected to the pump. The maximum power required for each motor is 190 hp., while the average power is practically constant at 160 hp. This station is fed from the main sub-station by a line of 400,000 circ. mil cable. The main disconnecting switch is shown at *A*, while the disconnects for each motor are shown at *C*. Box *B* contains the current transformers for the ammeters.

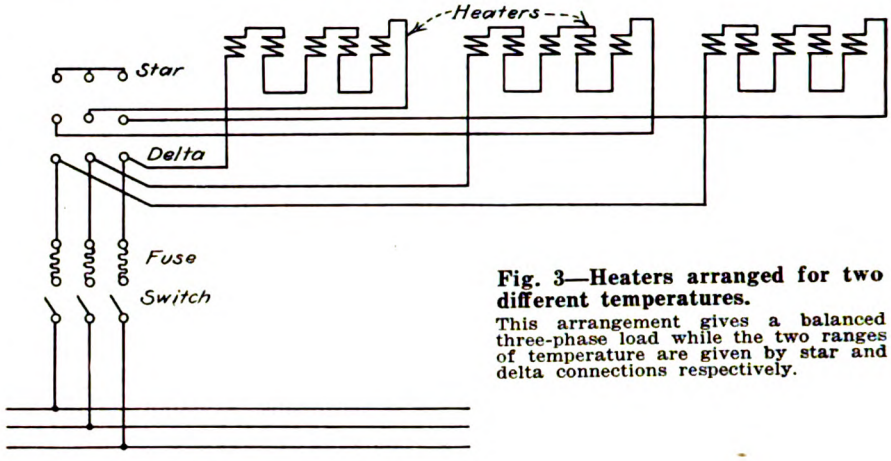


Fig. 3—Heaters arranged for two different temperatures.
This arrangement gives a balanced three-phase load while the two ranges of temperature are given by star and delta connections respectively.

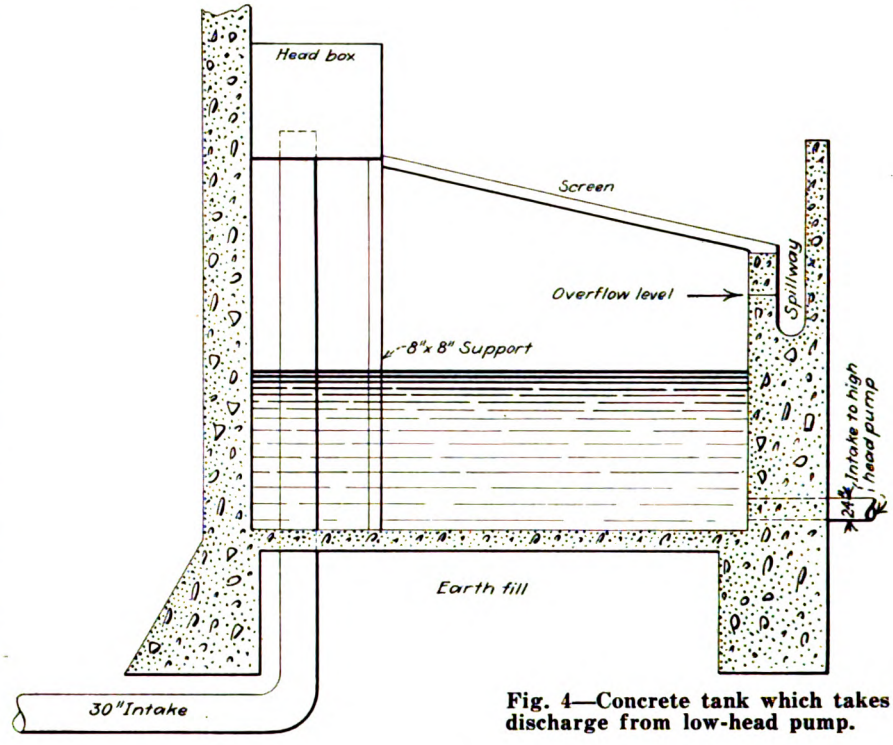


Fig. 4—Concrete tank which takes discharge from low-head pump.

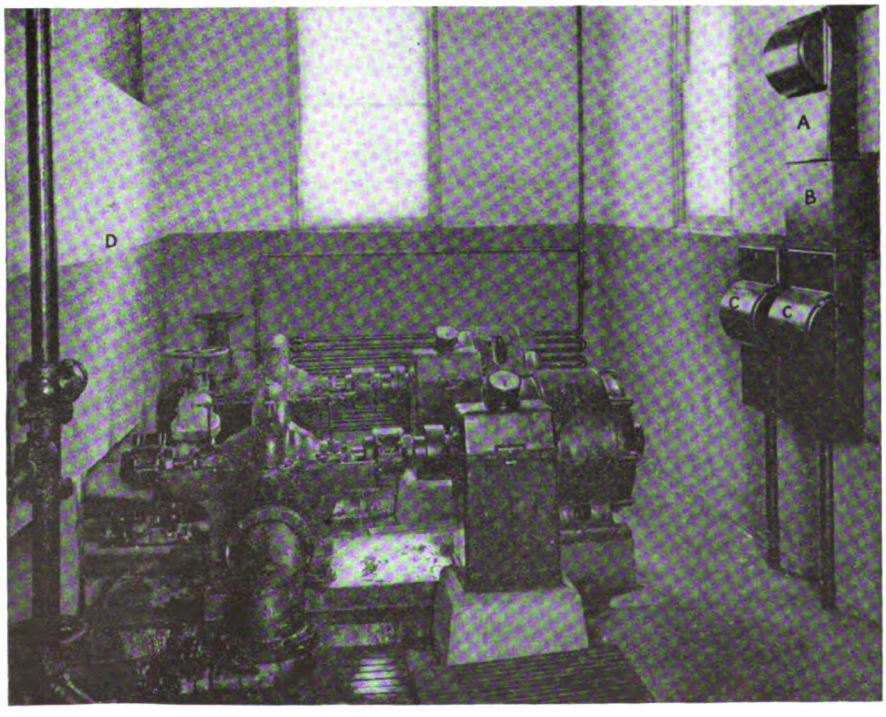


Fig. 2—A pumping room for delivering 11,000,000 gal. per day at 120-ft. head.
Each of the driving motors is rated at 175-hp., 550 volts, three-phase. The main disconnecting switch is at *A*, the motor disconnects at *C* and the compensators are pedestal-mounted near the motors. An ammeter on top of each compensator helps in starting and in operation. The current transformers are located inside of box *B*.

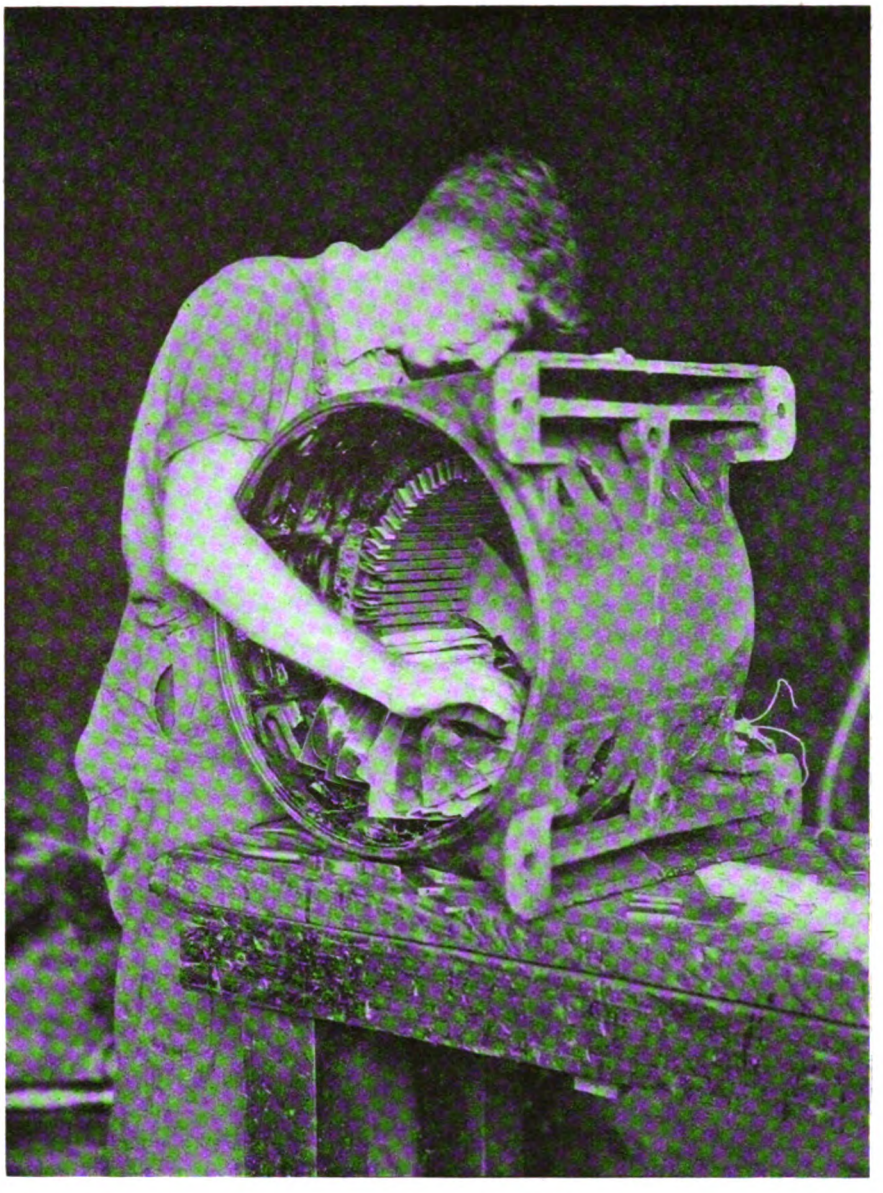
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OF COURSE if you have a diagram when winding a motor, you can follow it, but when a diagram is not available, to know how to make one to fit a particular case is worth a good deal. Furthermore, a knowledge of the principles of winding diagrams will enable you to tell what kind of a winding has been used on a certain motor and to check over that winding to determine if it is correct. Information of this sort is given in this series of articles. The present one covers three-phase induction motors. The article in the September issue covered single- and two-phase windings.

Steps in Laying Out and

Checking Up Three-Phase Diagrams

When Using Short and Long Jumpers with Star, Delta and Other Connections



BY A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company

THIS article gives details of methods for checking the windings of three-phase induction motors and for constructing diagrams to be followed in windings. The explanations cover the short and long types of jumpers for series and parallel windings with both star and delta connections. Laying out the diagrams is explained both for the developed type of diagram which shows all the coils of a winding and for the simpler single-line type of diagram which shows only the groups of coils. Similar information for single-phase and two-phase windings appeared in the September issue of INDUSTRIAL ENGINEER. In a later issue, special kinds of windings will be explained, as two-speed windings, star-delta connections, consequent-poles, and so on. To complete the information a later article will tell just how the various connections are made on an actual stator, giving practical directions for stubbing, connecting jumpers, insulating leads and taps, and so on.

PRINCIPLES INVOLVED IN THREE-PHASE WINDINGS

In a three-phase winding a 120-electrical degree relation must be maintained between the phases. At the same time modern motors, however, are so arranged that the coils are placed only 60 deg. apart. This is a fact that is hard to understand and gives a chance for mistakes. This relation will be explained fully after the principle of the three-phase machine is described.

In Fig. 1 is shown a simplified three-phase generator. In this generator there are three conductors placed 120 electrical and 120 mechanical degrees apart. Each one of these conductors generates a single-phase voltage which alternates from zero to a maximum, then back through zero to a maximum in the negative direction, finally returning to zero. This is explained more fully in a diagram on page 440 of the September issue of INDUSTRIAL ENGINEER. The three single-phase voltages follow each other in sequence. For instance, in position 1 the voltage in conductor *A* is zero while that in *B* has a positive value and that in *C* has a negative value. In position 2, when all of the conductors have advanced 15 degrees, *A* has a positive voltage which is increasing, *B* has a positive voltage which is decreasing and *C* has a negative voltage which is increasing in the negative direction. These conditions hold until position 3 is reached, when *C* is at its maximum in the negative condition. From this time *C* begins

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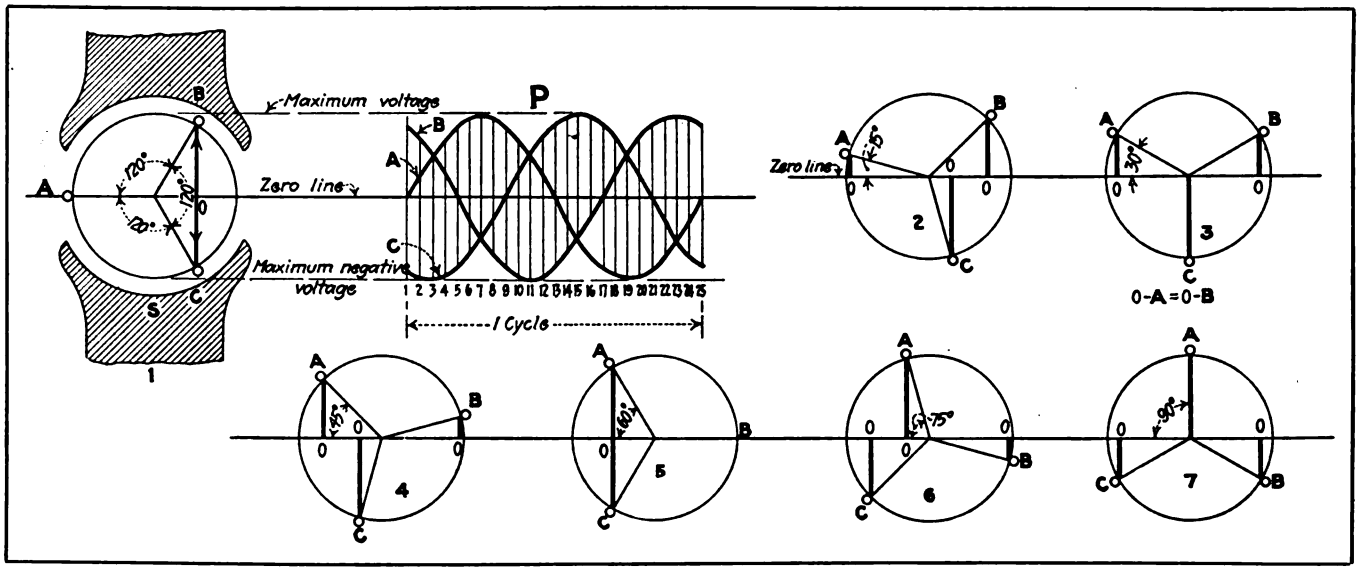


Fig. 1—Principle of a three-phase machine.
This is a simplified three-phase, two-pole generator with three conductors, *A*, *B* and *C*, located 120 degrees apart. As these revolve between the poles the voltages generated are equal respectively to the heavy lines, *A-O*, *B-O* and *C-O*, in the small drawings. The curves at *P* show the voltages generated during a cycle. Figs. 2 and 3 show the actual arrangement of coils in a motor.

to decrease. Voltage *A* continues to increase in a positive direction and *B* decreases until position 5, where it equals zero. Then *B* begins to increase in a negative direction as shown in position 6. The complete curves of all three of the phases are shown in *P* for one cycle.

A study of the voltages at any time will show that the sum of the three phases equals zero. For instance, at position 1, *A* phase equals zero, while *B* and *C* are equal but in the opposite directions; therefore, their sum is zero. In position 3, voltages *A* and *B* are positive while voltage *C* is negative. The sum of the three again equals zero.

The conductors shown in Fig. 1 are 120 mechanical degrees apart and at the same time 120 electrical degrees apart. In actual practice, however, this condition does not usually hold. Only in the case of consequent-pole windings are the adjacent groups 120 electrical degrees apart. In the case of practically all other windings the *A* phase and the *C* phase, for instance, are 120 electrical degrees apart, while the *B* phase is put in between these two, 60 degrees from each one. The correct electrical relation is accomplished by reversing the direction of the current through this *B* phase, which results in the final arrangement of 120 electrical degrees difference between each pair of phases. This is well illustrated in *D* and *E* of Fig. 8. This 60-degree arrangement is one of the pitfalls of three-phase windings and it should be thoroughly understood.

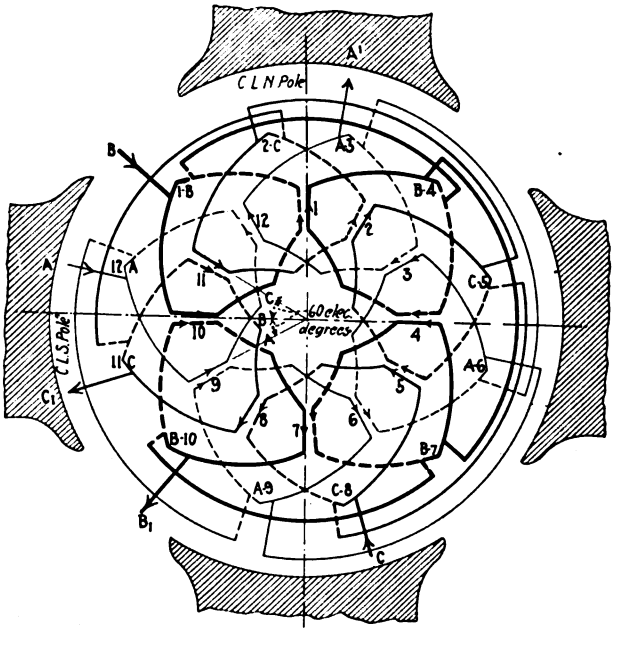
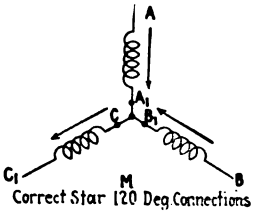
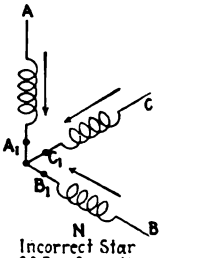


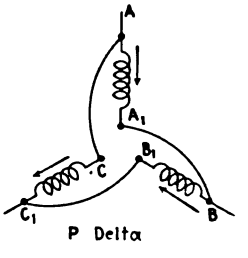
Fig. 2—Arrangement of coils in a three-phase motor.
The large drawing shows how in an actual motor the groups of adjacent phases are only 60 electrical degrees apart instead of 120 deg. apart as shown in Fig. 1. This is explained in the article. The large diagram is for a four-pole, three-phase winding in which there are twelve slots and twelve coils. There is one coil per pole per phase, therefore one coil forms a group. The full pitch is $(12 \div 4)$, equals 3 slots spanned or 1-and-4. The jumpers are connected top-to-top. Single-line diagrams applying to the winding are shown in Figs. 4, 5, 7 and 8. At *M* is shown a schematic diagram of the motor winding connected correctly so as to give a 120-deg. relation of the phases although the groups are actually 60 electrical degrees apart. This condition is accomplished by reversing one of the phases, the *C* phase in this case. At *N* is shown the incorrect 60-deg. connection which results if one of the phases is not reversed, as at *M*. Diagram *M* shows a star connection. Diagram *P* shows how the delta connection is obtained.

Constructing a Developed Diagram for a Three-Phase Machine

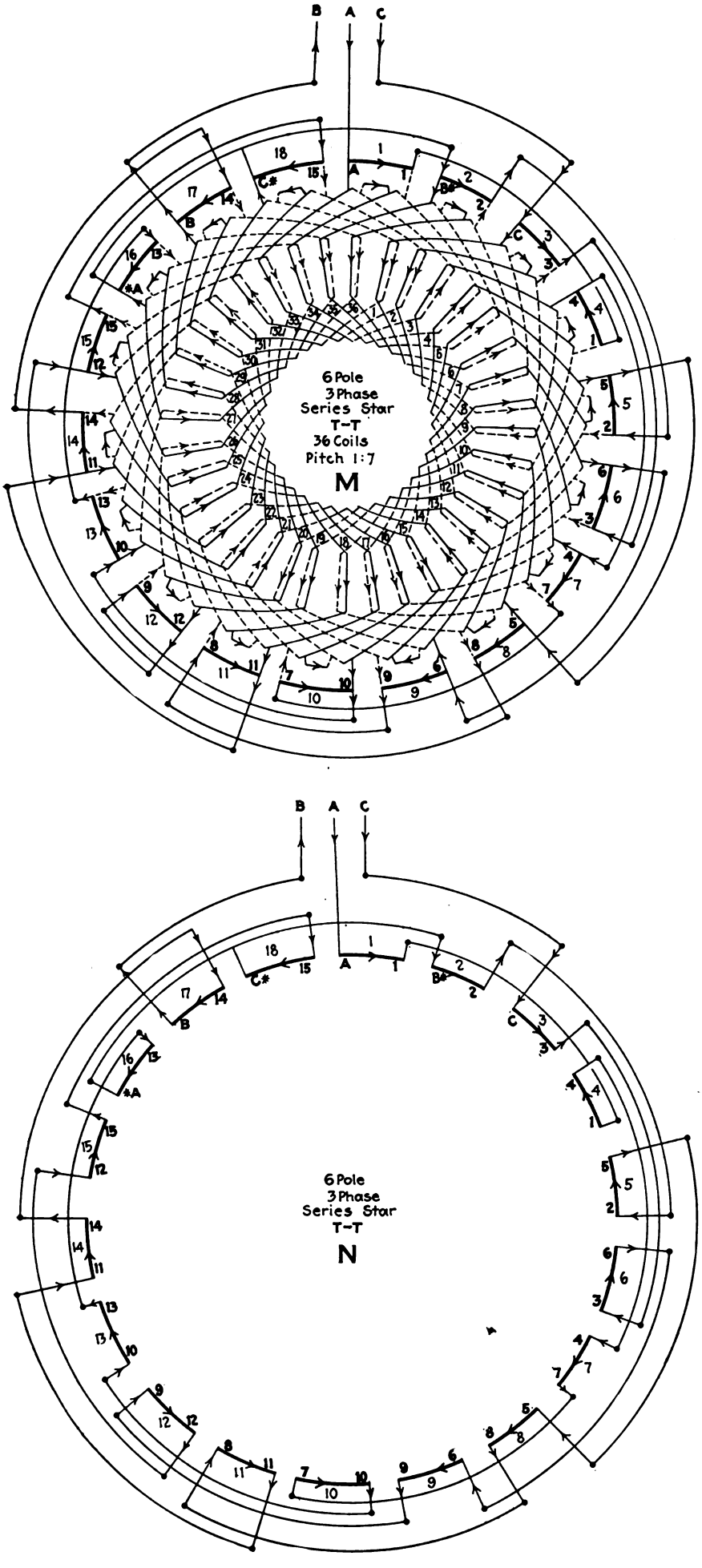
A three-phase winding is essentially three single-phase windings, all on the same core. After each single-phase winding is connected up, then the three windings are connected either in star or in delta, as the case may be. To draw a developed diagram of such a winding radial lines representing the coil sides in slots are first laid out as shown in Fig. 2. Then the coil pitch is determined. In Fig. 2 is shown a four-pole, three-phase winding with twelve slots. Since there are







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twelve slots and four poles, the pitch will be equal to three slots or 1-and-4, which is full pitch. Sometimes a "chorded" pitch is used, in which case the number of slots spanned by a coil might be less than four and sometimes even greater. After the conductors in the slots are drawn, then the coils are drawn in as illustrated in Fig. 2. After the coil ends are drawn the arrows are put on the top conductors, all arrows under one pole space pointing in the same direction, while those under the next pole space point in the opposite direction. The arrows on the bottom sides of the coils are put in after the end connections of the coils have been drawn. Their direction is determined by tracing around the coils to see in which direction the current would flow.

The next thing to do is to connect the coils in groups. In this motor there should be 3×4 groups, as there are three phases and four poles. With twelve groups and twelve coils, this equals only one coil per group. Every third coil in the diagram will belong to the same phase. For instance, coils 1, 4, 7 and 10 belong to phase *B*. For the *B* phase then we may start at coil 1 and call the top lead an ingoing line lead. The next adjacent group of this phase is coil 4. The ingoing lead of this coil is a bottom lead; therefore, the bottom lead of coil 1 and the bottom lead of coil 4 are connected together. Likewise the top lead of coil 4 is connected to the top lead of coil 7, as the current is passing inward on this top lead. Then the bottom leads of coils 7 and 10 are connected together. The final lead of the *B* phase is the top lead of coil 10. This is called B_1. The other two phases are then connected up in the same manner, using any ingoing lead as the starting point and connecting every third coil together. After this is completed there will be six leads left, two for each phase. In order to use this motor on three-phase voltage, the winding must be connected in either star or delta.

As we have already seen from Fig. 1, there is as much current flowing

Fig. 3—How a simple single-line diagram is drawn from a developed diagram.

The heavy lines are put on the outside of each group as shown at *M*. Then the interior is removed, as shown at *N*, leaving the single-line diagram. This is a six-pole, three-phase winding connected with top-to-top jumpers in series-star. The same single-line diagram is used in Fig. 12.

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into a three-phase winding as there is flowing out of it. Therefore for the line leads in Fig. 2 we must take one ingoing lead and one outgoing lead. For a series-star connection leads *A*, *B* and *C*¹ might be used for line leads and *A*¹, *B*¹ and *C* connected together to form the star. Or any other combination of leads might be used in which one outgoing and two ingoing leads are employed for line connections, or two outgoing and one ingoing lead are employed.

Beware of the 60-Degree Connection in Three-Phase Windings

There is a chance to make a wrong connection in three-phase machines, which is not present in one- or two-phase windings. This is the 60-degree connection which has already been mentioned. For instance, suppose that leads *A*, *B* and *C* were connected to the line while *A*¹, *B*¹ and *C*¹ were joined together to form the star connection. This would give a 60-degree connection as shown in *N* in Fig. 2, while the correct connection should be as shown at *M*. A machine connected as at *N* would not run as a motor nor deliver power as a generator. If the phases were equally balanced no current would flow, but if there were an unbalance present a circulating current would flow.

As a general rule, for a correct 120-degree star connection the line leads may be selected as follows: Take one group of any phase and call this group 1. Then count over to group 3 on each side of this group 1, and the two groups so found can be used for line leads. If a top lead were selected in the first group, top leads must be used also on the other two groups. Or if desired all the leads can be bottom leads. A 60-degree (incorrect) connection is shown in the single-line diagrams in Fig. 6.

A delta connection seems to some winders harder to understand than a star connection. However, as shown in *P* of Fig. 2, the delta connection is not hard if it is always remembered that one of the phases must be reversed. In other words, the phases are connected in series and the current, according to the arrows which have been put upon the slots, must be the same when passing through the series in one direction for only two of the phases. The other phase must be reversed and bucking the first two phases. The reason for this is that the sum of the currents in any two phases equals the current in the other phase but is in the opposite direction. In other words, the sum of all three currents equals zero.

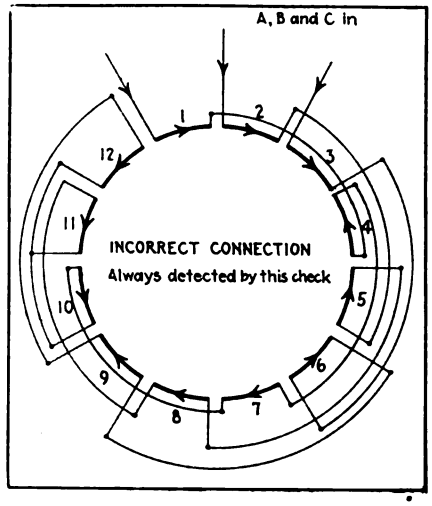


Fig. 5—The "all-in" check shown in this diagram will always detect an error in connections.
In the "all-in" check the arrows are placed pointing inward on all three leads. If the diagram is correct the arrows on the groups will alternate in direction. One group will point clockwise, the next group will point counter-clockwise, and this will be repeated throughout the winding. The check proves that the winding shown here is connected wrongly because there are three arrows on the groups in one direction. If the *B* phase were reversed the connection would be correct. The *B* lead should connect to the lower lead of group 11 and the star connection should go to group 2 on what is now the *B* lead.

How the Simpler Single-Line Diagram Is Constructed

A simpler type of diagram than the developed diagram in Fig. 2 may be used. This simple diagram is called the single-line diagram. In Fig. 3 is shown the principle of the single-line diagram and the way in which it may be obtained from the developed diagram. Across the end of each group of coils in the developed diagram shown at *M* a heavy line is drawn. Arrows are put on these heavy lines, pointing in the

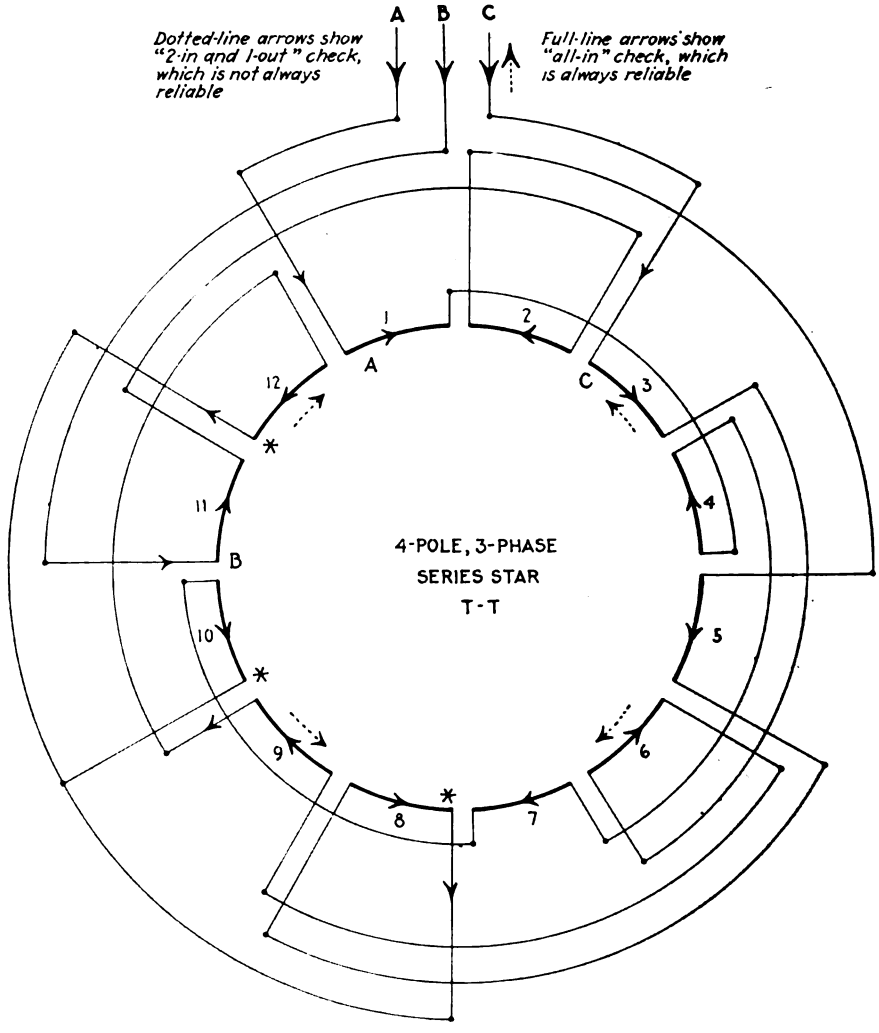


Fig. 4—How to check single-line diagrams by means of arrows.
The most reliable way to check a single-line diagram is shown by the full arrows. These arrows on alternate groups reverse direction. This is possible only when the arrows on the leads *A*, *B* and *C* all point *inward* (or all outward). The dotted arrows show the direction of current as taken from the developed diagram as Fig. 2 or Fig. 3. In this case the arrows on two leads (*A* and *B*) point inward while that on the *C* lead points outward. This latter arrangement of arrows will not always give a certain check as is demonstrated in Fig. 5.

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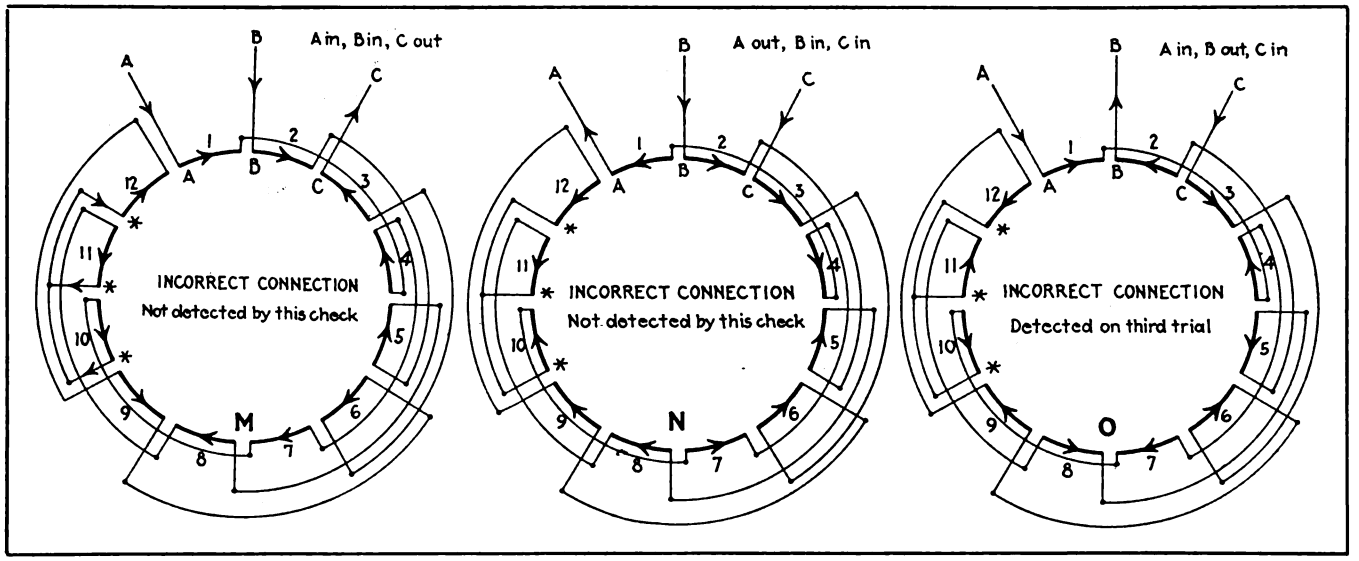


Fig. 6—This kind of arrow check is not always reliable.

This diagram shows the check where the arrows on two leads are pointed in, while that on the other is pointed out. Now when this check is used the rule is that three adjacent groups will have arrows in one direction while the next three groups will have arrows pointing in the opposite direction. This is repeated around the diagram. But as shown, three checks of this kind must be made. The diagram is drawn incorrectly, as the wrong end of the *B* phase is connected to the line, yet the checks at *M* and *N* fail to disclose the error. The third check, at *O*, shows that the connection is incorrect. Instead of this kind of check it is safer always to use the check shown in Fig. 5.

same direction as those on the stub connections from one coil to another in the group. Then the drawing inside of the heavy lines is cut out in order to leave the single-line diagram alone. Each of the heavy single lines then represents a group of coils. For the particular drawing shown at *M*, these lines represent two coils each. However, the same diagram will hold for a group of any number of coils.

The leads coming out of these single lines, as shown at *N*, are lettered. For instance, in group 1, the letter *A* is put at the end of the heavy line which connects to the line lead *A*. All of the leads which connect to lines are lettered in this way, *A*, *B* and *C*. Then opposite the star leads a star is placed, as in groups 16, 18 and 2. After this the other leads are numbered. Starting at group No. 1, the first lead which does not have a number is given the number 1 and a figure 1 is written underneath this lead as shown. This lead connects by means of a jumper to a lead in group 4, and a figure 1 is also put at the end of group 4, as shown. Then going back to group No. 2, the next lead which is not numbered is the bottom lead. This is given the number 2. In the same way as before, this connects with a lead in group No. 5, and this bottom lead in group No. 5 is also called No 2. The leads are taken up in this way in succession around the diagram until every lead has a number. Then, it is known that the leads which have the same number are connected together by jumpers.

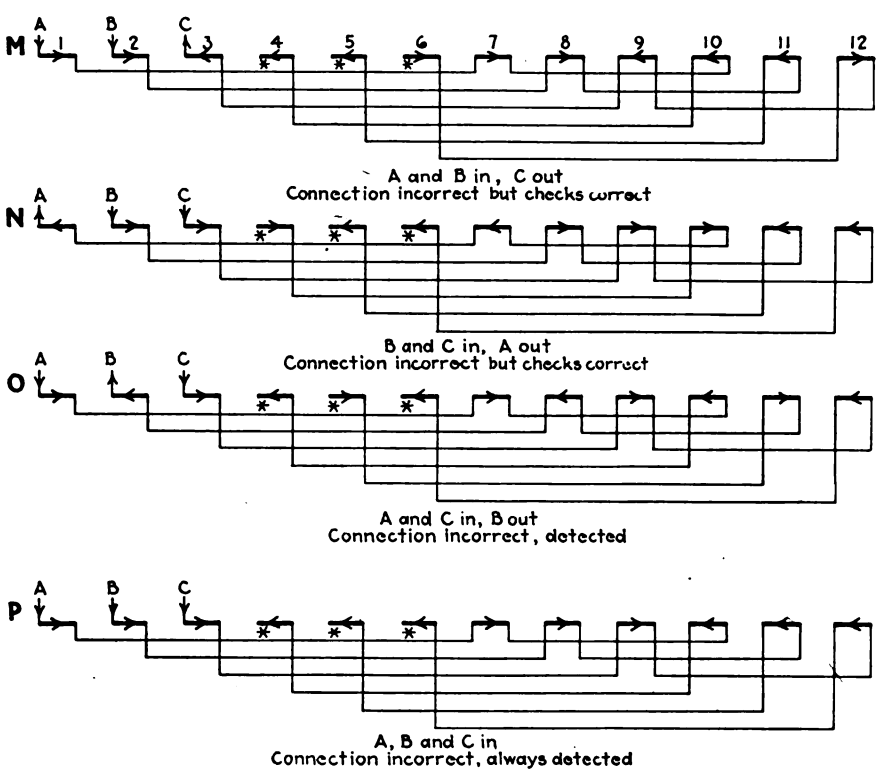


Fig. 7—The right and the wrong way to check windings.

This shows a long-jumper type of connection checked in the reliable way at *P* and the unreliable way at *M*, *N* and *O*. At *M*, *N* and *O* the arrows are put on the leads, two inward and one outward. With arrows in these directions the arrows on the groups shown point first three in one direction, then three reversed, and so on. They do this in *M* and *N* even though the connections are wrong. The third check of this kind, at *O*, does show the mistake. The check shown at *P* detects the error at once. In this check all the arrows on the leads point in one direction. Then the arrows on the groups should alternate on alternate groups. They fail to do this in the diagram at *P*, therefore this diagram is incorrect. Figs. 5 and 6 also illustrate the value of the "all-in" check.

How to Construct a Single-Line Diagram

In constructing a single-line diagram, the first step is to draw the heavy single lines in a circle, as shown at *N* in Fig. 3. There is one heavy line for each group in the winding. The next step is to put on the arrows showing the direction of current in the group, but this should not be done as it is done in Fig. 3. In this figure, the arrows in the first

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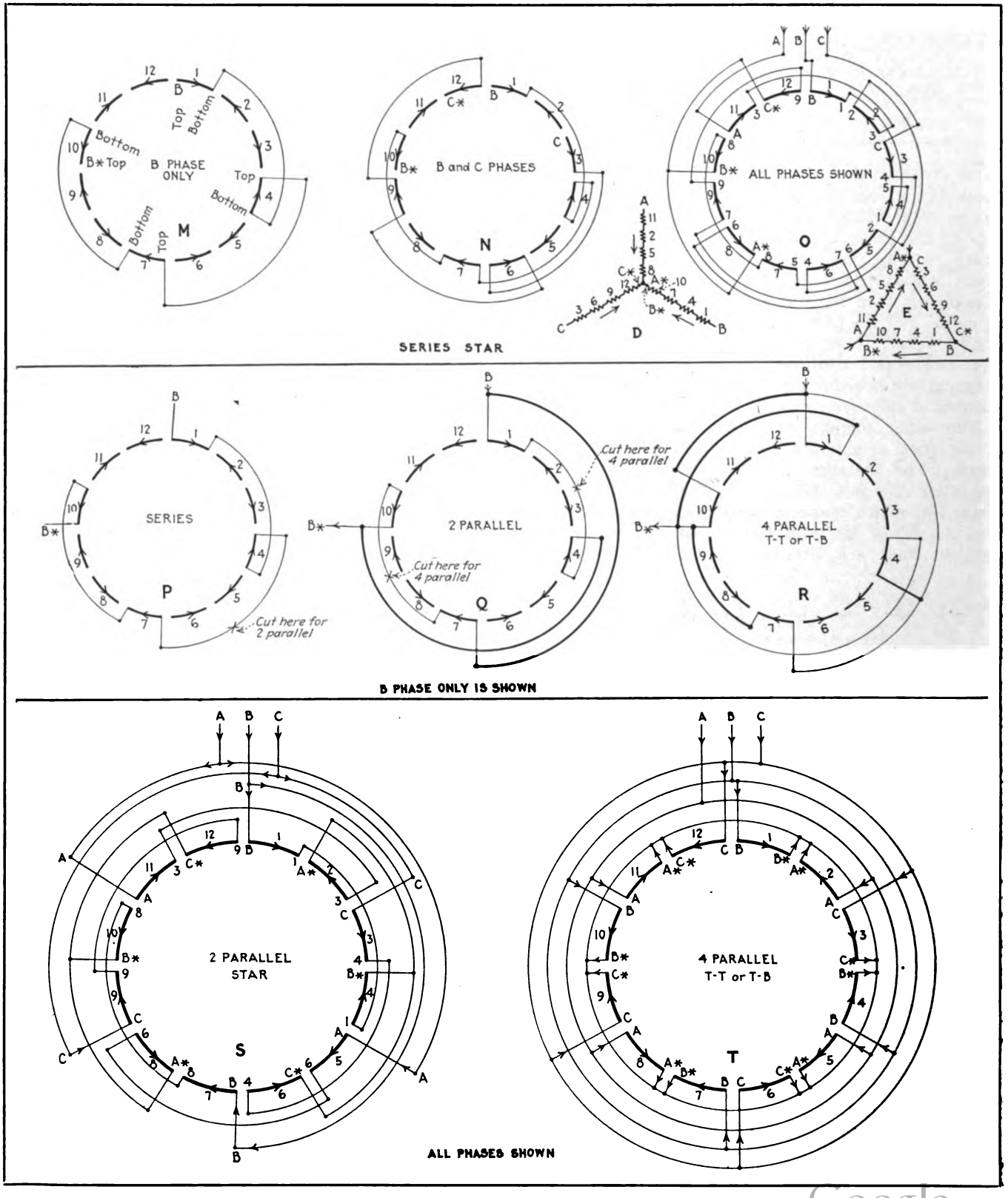
three groups point clockwise and the arrows in the next three groups point counter-clockwise, and this is continued around the winding. However, in constructing a single-phase diagram from the data, the arrows should be put on as shown in Fig. 8 at *M*. The arrows in this diagram alternate, first one arrow pointing in one direction, then the next in the opposite direction. The reason why the arrows should be put on in this manner will be explained in the following paragraphs.

Fig. 8—How single-line diagrams are drawn, both series and parallel.

Drawings *M*, *N* and *O* show three steps in making a single-line diagram, while drawings *P*, *Q*, *R*, *S* and *T* show how the series winding is changed to two-parallel and four-parallel. The drawings are all for a four-pole, three-phase star winding with top-to-top connections. Only the *B* phase is shown in *M* and *N* while all three phases are drawn in *O*. In the drawings *P*, *Q* and *R* the heavy lines show where changes have been made from the preceding drawing in order to get the two-parallel or four-parallel connection. Drawings *P*, *Q* and *R* show only the *B* phase but all three phases are shown in *S* and *T*.

How the Arrows Should Be Put on a Single-Line Diagram

Let us check the winding shown in Fig. 4, for instance, by placing on arrows in the same way as they were placed in Fig. 3. In Fig. 3, the arrows on the line leads are arranged with two pointing inward and one outward. With arrows placed in this



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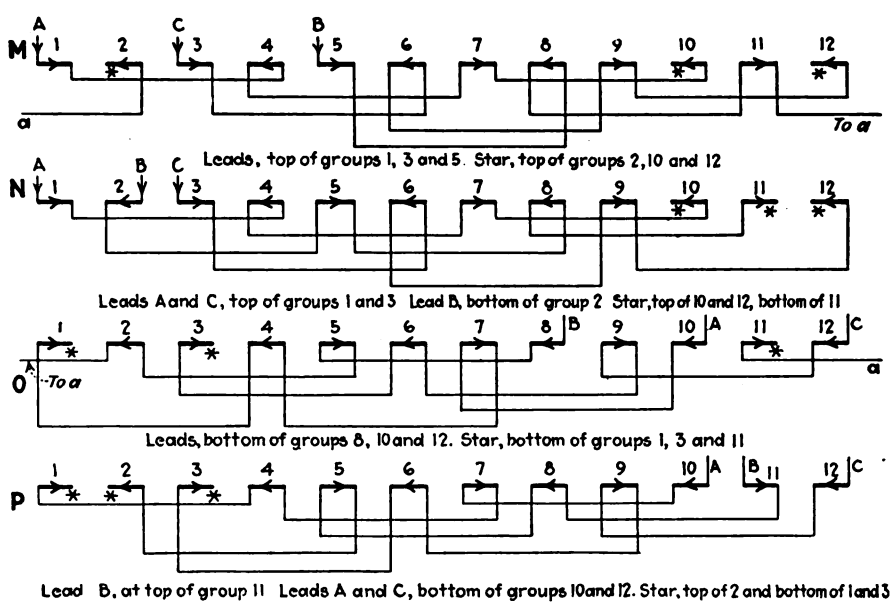


Fig. 9—Various positions in which line leads may be placed.

These diagrams are all for a four-pole, three-phase, series winding with top-to-top connection (short jumpers). As will be seen, the line leads are put on in four different ways, but each is correct.

way on a correct diagram, the arrows on the groups will alternate, first three groups pointing in one direction, and the next three groups in the opposite direction. This check, however, is not always reliable, as will be explained later, because sometimes the arrows in the groups may point in the correct direction and yet the winding may be incorrect. In Fig. 4 the arrows drawn in full lines show the correct method of checking the groups, while those drawn in dotted lines show the unreliable method, or that used in Fig. 3. For the correct check as shown in Fig. 4, the arrows point inward on all of the line leads. The arrows on the groups alternate first in one direction and then in the other entirely around the winding.

To prove that the "two in and one out" method of checking is not always reliable, let us examine Fig. 6. This shows the unreliable check applied to a four-pole, three-phase, series-star diagram. This gives three cases of using this check. In each case, two of the arrows on the line leads point inward, while one points outward. In *M* and *N* the arrows on the groups point in one direction on three groups and then in the opposite direction on the next three groups, and this is repeated around the diagram. According to the rule for this check, this would indicate that in both of these cases the diagram is correctly drawn. However, by a third application of the same check in *O* of Fig. 6, it is found that the arrows on the diagram alternate, first in one direction and then in the other. For this kind of a check, this shows that the connections are not correct. In the two cases of *M* and *N*, where the same check was applied, however, the mistake was not detected.

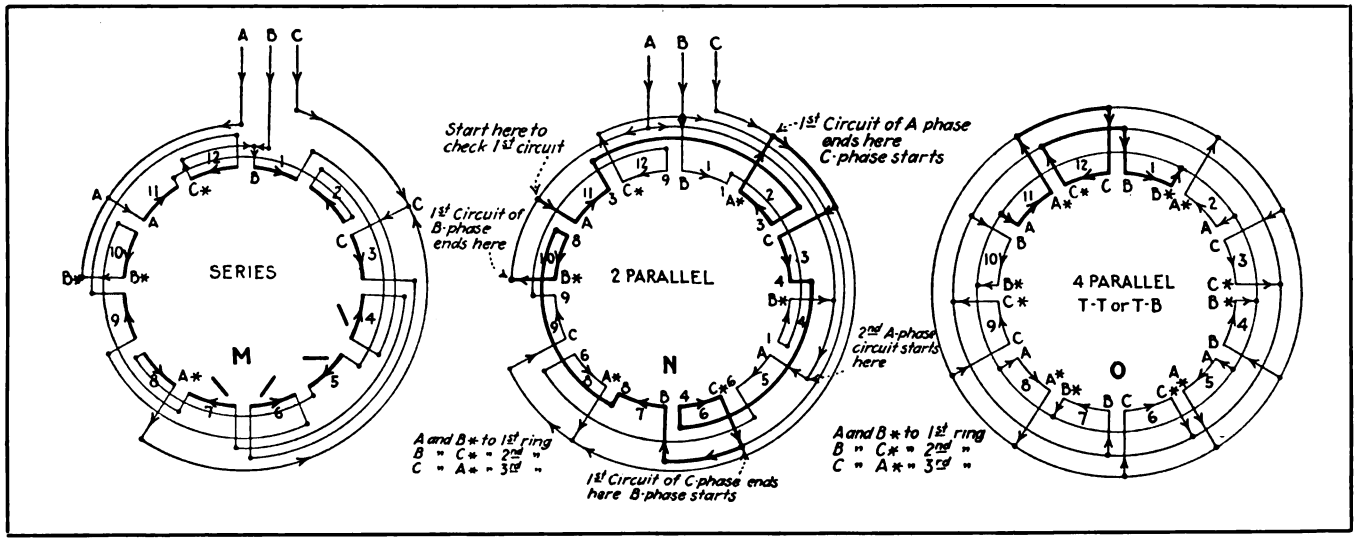
In applying the check shown in Fig. 5, all of the line leads have the arrows pointing inward. Then, the current is traced through all of the groups and arrows put on them according to the direction of the current. Finally, if the arrows alternate, first in one direction and then in the other entirely around the windings, the connections are correct.

It is seen in Fig. 5, however, that the arrows do not alternate in this way, and, therefore, the diagram in Fig. 5, which is the same as that in Fig. 6, is not correct.

In Fig. 7 again is shown the reliability of the "all in" method of checking and the unreliability of the "two in and one out" method. The checks are applied in Fig. 7 to the long type of jumper, while the diagrams shown in Figs. 5 and 6 have the short type of jumper. All four of the diagrams shown in Fig. 7 are the same, and the connections are incorrect. By applying the checks in *M* and *N*, however, no error is detected. The "two in and one out" method does detect an error in *O*, but this might be the third trial, as it does not detect it in *M* and *N*. However, the "all in" check shown

Fig. 10—Delta-connected windings, series and two-parallel.

These drawings show a four-pole, three-phase winding connected top-to-top. The heavy oblique lines inside the circle at *M* show how chalk marks may be put in an actual stator to indicate the direction of flow of current. The heavy lines in *N* show how to check a two-parallel, delta winding. One of the two parallel circuits has been checked by following the black lines. At *O* is the four-parallel diagram. The heavy lines show the path in checking one of the four parallel circuits.



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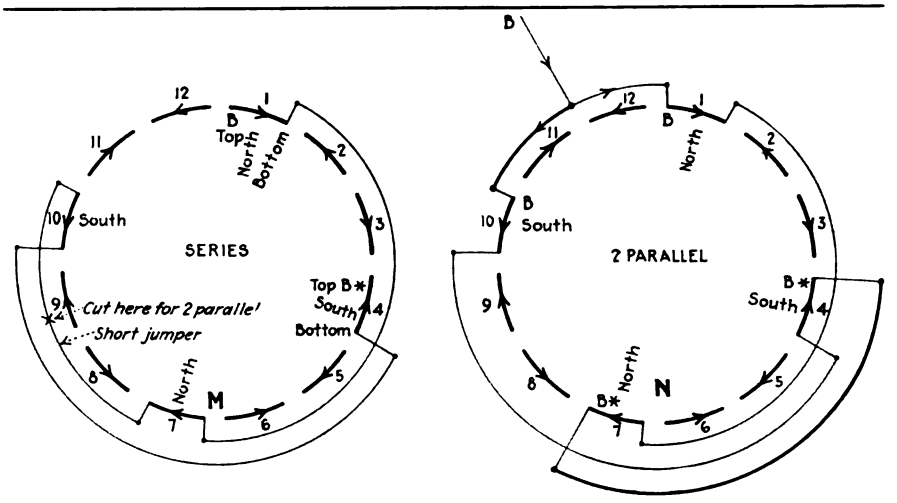


Fig. 11—Top-to-bottom type of connection, series and two-parallel. This shows a four-pole, three-phase, star winding with the top-to-bottom, or long, jumper. At *M* is a series connection, while at *N* is a two-parallel connection. The heavy lines in *N* show where changes have been necessary to convert the series to the two-parallel connection.

in *P* never fails to detect the error. As seen in *P*, the arrows point, first, three in one direction and then three in the opposite direction, and this shows that the connection must be wrong. For this "all in" check, the arrows in the groups must alternate, the first arrow in one direction and the second arrow in the other direction, and so on.

Therefore, in checking the single-line diagram, the arrows should be put on as shown in *M* of Fig. 8, the arrows on the line leads all pointing inward and those on the groups alternating first one arrow in one direction, then another in the opposite direction. This check is based on the fact that if direct current flows inward from each line of a properly connected series motor, and a compass is held against each group, the polarity of each successive group will reverse.

Therefore, in constructing the single-line diagram, first the arrows are put on the groups, making one arrow point first in one direction and the next arrow in the opposite direction, and repeating this around the winding as in Fig. 8. Then, put the group numbers on the curved lines. In any three-phase winding, every third group (1 and 4) belongs to the same phase. The alternate groups of the same phase are in poles of opposite polarity. In other words, if group No. 1 is in a north pole, then group No. 4 will be in a south pole. Similarly, group No. 7 will be in a north pole.

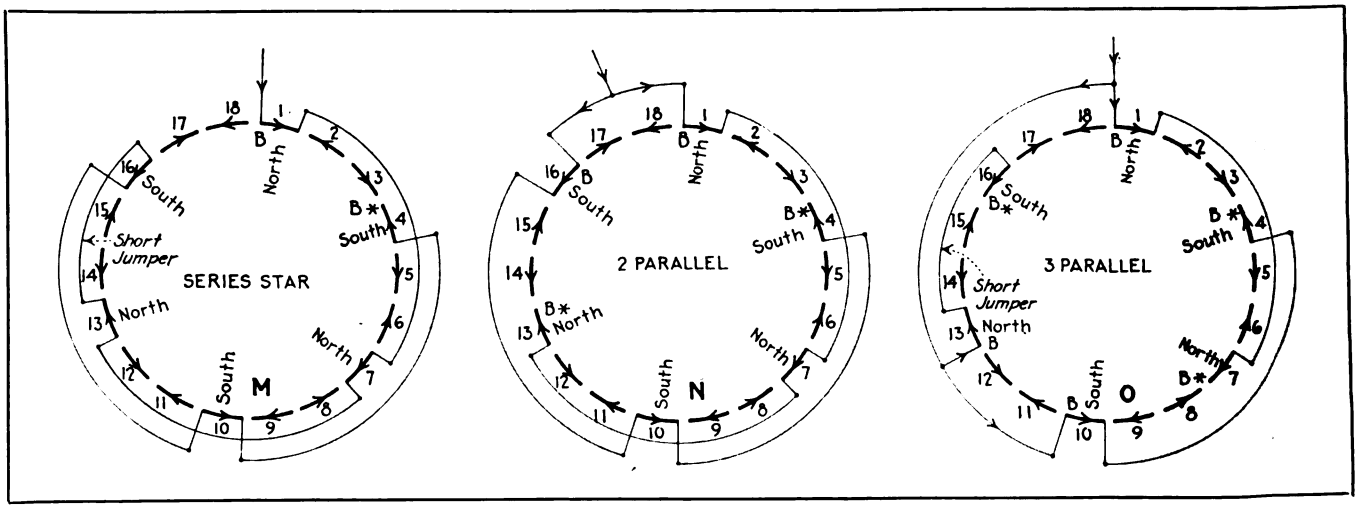
For a top-to-top connection adjacent groups of the same phase are connected together. For a top-to-bottom connection all groups in the north poles are first connected in series and then a short jumper is used to connect this series with the series of all south poles. The difference between the top-to-top (short) jumper and the top-to-bottom (long) jumper is explained fully on page 467 of INDUSTRIAL ENGINEER for September.

The diagram in Fig. 8 is for a top-to-top connection; consequently the first group is connected to the fourth. Calling the top lead of group No. 1 the *B* line, then connect groups No. 1 and No. 4 together, so that the arrows are followed. In other words, the bottom of group No. 1 connects to the bottom of group No. 4. Groups No. 4 and No. 7 are next connected together. The top of group No. 4 is connected to the top of group No. 7. Then, the bottom of group No. 7 is connected to the bottom of group No. 10, and as all the groups in the *B* phase have been covered, the top of group No. 10 is the star connection. In passing through this series of groups from one end to the other, it will be noted that the passage is first clockwise (in group 1), then counter-clockwise (in group 4), then clockwise (in group 7) and then counter-clockwise (in group 10). In other words, the direction alternates from one group to the next. This holds always with the top-to-top connection, but with the top-to-bottom connection the first series of groups is passed in one direction and the second series in the opposite direction.

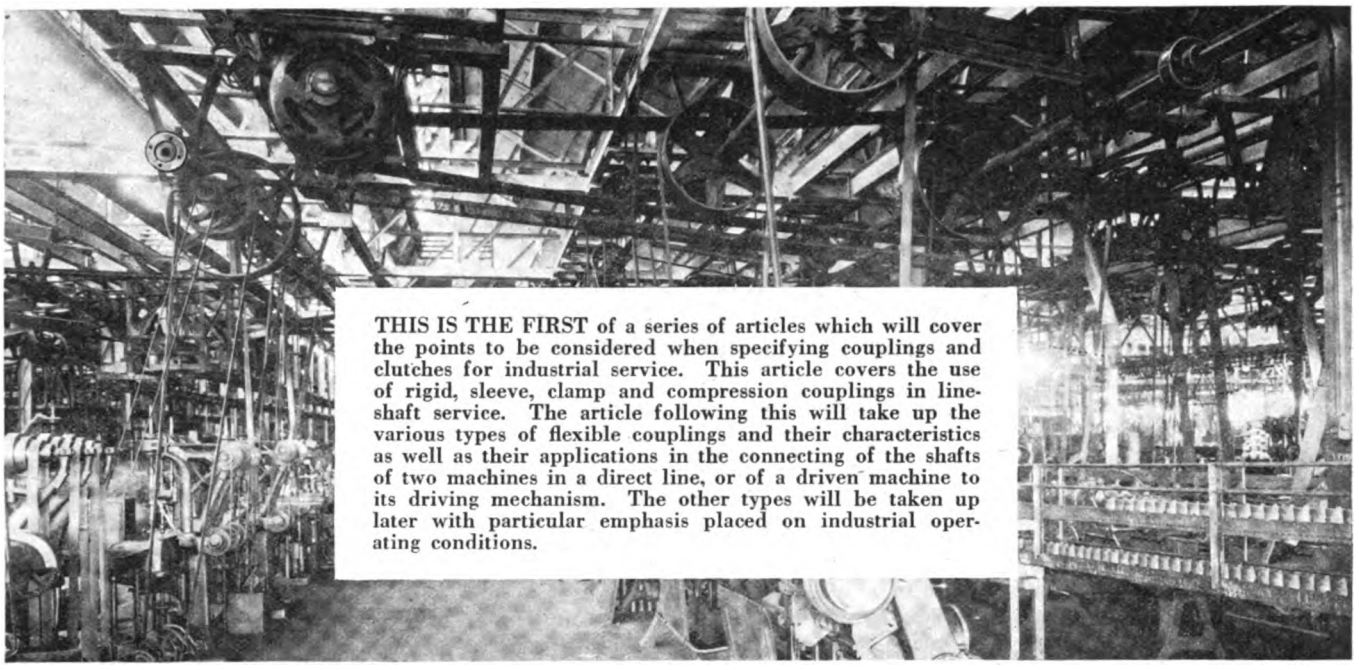
In Fig. 8 after the *B* phase is connected as in *M*, the *C* phase is drawn in, as shown in *N*. To locate the start of the *C* phase, count over from group 1 to 3. Then the *C* line will connect to the top lead of group 3. The bottom of group 3 will connect to the bottom of group 6. Then the top of group 6 connects to the top of group 9, the bottom of 9 connects to the bottom of 12, and the top of group 12 forms the second star connection. After this phase is drawn, check it as outlined for the *B* phase.

The line *(Continued on page 516)*

Fig. 12—Six pole winding connected series and parallel. This is a three-phase star winding with top-to-bottom (long) jumpers.



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THIS IS THE FIRST of a series of articles which will cover the points to be considered when specifying couplings and clutches for industrial service. This article covers the use of rigid, sleeve, clamp and compression couplings in lineshaft service. The article following this will take up the various types of flexible couplings and their characteristics as well as their applications in the connecting of the shafts of two machines in a direct line, or of a driven machine to its driving mechanism. The other types will be taken up later with particular emphasis placed on industrial operating conditions.

Some Factors Which Affect the

Use of Rigid and Compression Couplings

When Employed in Connecting Lineshafting in the Mechanical Transmission of Power in Industrial Works

By FRANK E. GOODING
Associate Editor, Industrial Engineer

WHERE several machines are operated together, as in many shop drives, lineshafting is used to convey power from the motor, engine or other source of power to the point where these individual machines are located. Because such a line of shafting is usually made up of several sections, the ends of these sections must be joined by some form of coupling.

Flange couplings, clamp couplings, sleeve couplings or compression couplings are generally used and the choice is made depending upon the amount of power to be transmitted, upon the speed at which the shaft revolves, and upon how often the shafts may need to be disconnected, or upon the kinds of pulleys, bearings, clutches, etc., that it may be desired to mount upon the shaft.

However, in connecting the ends of the shafts of two or more individual machines, especially if they are to operate at high speed, such rigid couplings are usually not satisfactory and flexible couplings are preferred. The numerous types of these flexible couplings, their characteristics and application will be taken up in the next article.

All the sections of lineshafting should be carefully lined up in the first place and they should be realigned occasionally to prevent too great a loss of power through excessive bearing friction caused by misalignment. However, as the bearings and hangers are usually several feet apart, a slight error in the alignment due to improper aligning at the start, due to a slight shifting of the hangers, or due to unequal bearing wear is taken care of by a bending of the shaft. This, however, is very wasteful of power; in some cases half the power is wasted in bearing friction. When a shaft shrieks or squeals when starting or stopping, usually it is a sign that it is badly out of line. Flexible couplings might be used to overcome part of this waste but they are more expensive to install and they are not necessary because the shaft should be and usually can be kept in reasonable alignment at less expense.

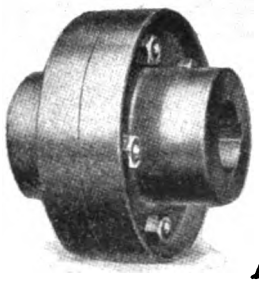
Some Types of Rigid Flange or Plate Couplings

The most common type of rigid couplings is the flange or plate coupling shown at *A*. These are made for all sizes of shafts and are for the primary purpose of rigidly connecting two lengths of shaft sections to make one continuous section. On more or less semi-finished work such as low-speed transmission shafting, these flange couplings may be forced on the ends of the shafts and keyed in position. For this semi-finished work often only the bore, face and outer rim of the couplings are finished. The bolts may have considerable clearance in the bolt holes. The usual test of alignment is to see that the outer rims of the flanges fit together. When it is desirable to center the flanges one with the other, one shaft may be extended through its flange into the bore of the other flange, as shown at *D*, or one flange may be made male and the other flange female by cutting a groove in one flange and a shoulder in the other to fit into it, as shown at *B*. Usually the groove and shoulder are placed outside the bolt holes near the rim. To remove a length of such shafting it is necessary to slip

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Examples of Rigid and Compression Couplings

Construction of Various Types for Lineshaft Use



A

A—The flange or plate couplings are the most common for lineshaft work.

B—The groove and shoulder of the male and female flange coupling.

C—One type of clamp coupling which is easily applied or removed.

D—The end of one shaft is inserted into bore of the other to affect alignment in flange couplings.

E—Two flanges on a slotted tapered sleeve give sufficient compression without keys.

F—These rings are driven over the ends of the tapered two half-sleeves.

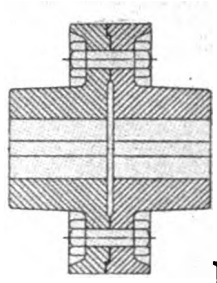
G—The "Pintite" coupling, in which pins are driven through side of shaft and form their own keyway.

H—In this compression coupling two cone rings are bored tapering to fit the outside of the sleeve and are held in place by a threaded-in-collar.

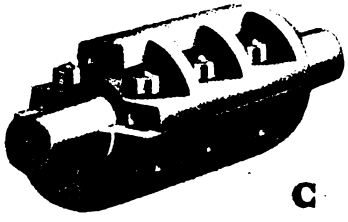
I—A cross-section of the cone-ring compression coupling *H*.

J—A double-cone compression coupling, pulled together by bolts, makes a very strong coupling which is easily attached or detached.

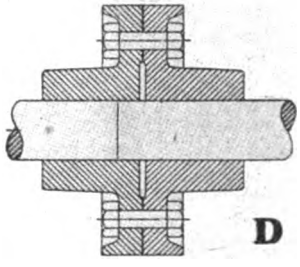
K—A cross-section which shows the assembly of coupling *J*.



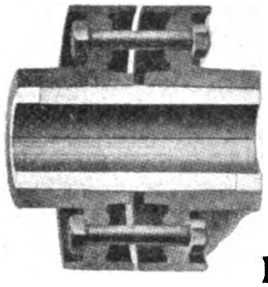
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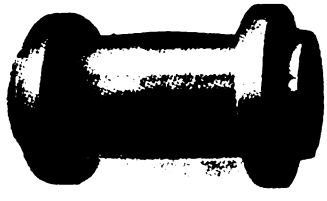
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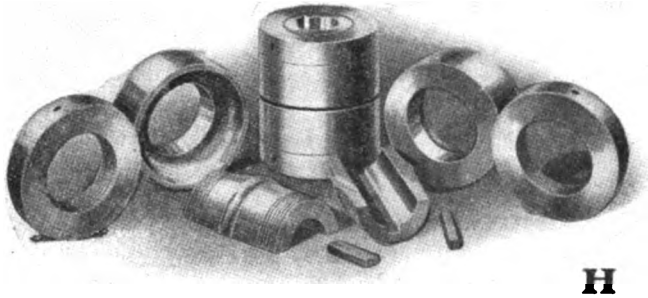
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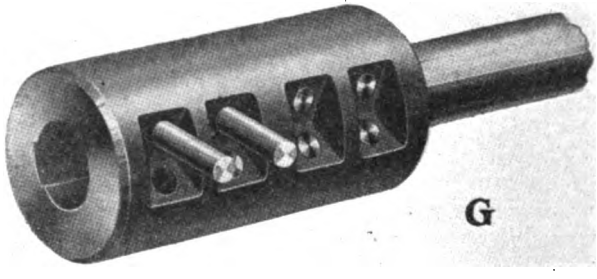
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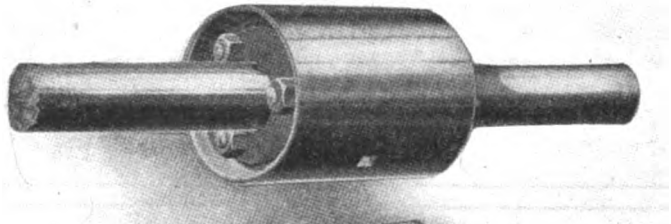
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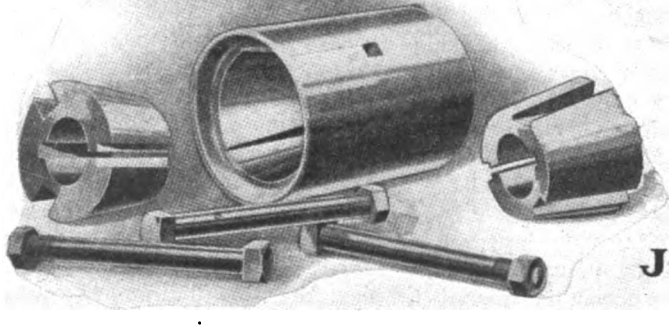


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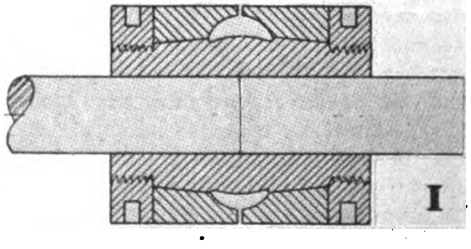


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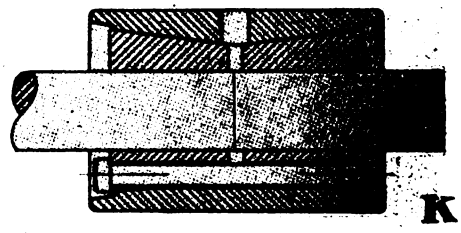




J



I



K

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the shafting lengthwise, a distance equal to the shoulder.

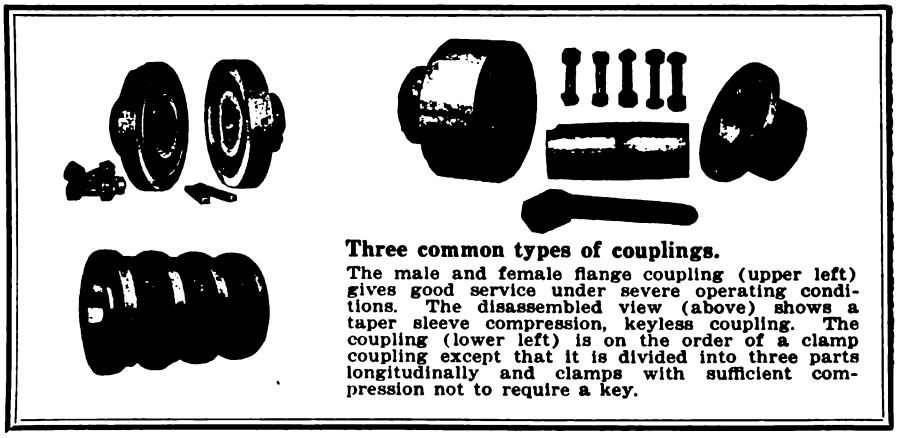
For high-speed transmission shafting the usual practice is to mount the flanges on the ends of the shafts and then key in position, after which the shaft is put in the lathe and the flanges are trued up with the shaft. Frequently the bolt holes are also reamed through and body-bound bolts are used to get the full effect of the strength of the bolts as well as the friction drive between the faces of the flanges. This type of coupling is used almost exclusively for coupling 6-in. or larger lineshafting.

Occasionally, seasonal or other periodical fluctuations of production make it advisable to have infrequent disconnection of the shafts so that parts of a line only need be operated. For such places regular flange couplings can be fitted with separating plates between the coupling halves. These plates are usually cast iron half rings machined over-all and with reamed holes for the coupling bolts. When the shafts are to be disconnected the coupling bolts are removed, the separating plate taken out and the coupling halves are no longer connected.

Standard flange couplings are usually conveniently stocked in most mill supply houses. An extra charge is usual for male and female couplings as well as for reducing couplings which are used for connecting shafts of different diameters. Flange couplings are often pressed on the shafts and therefore are difficult to remove if occasion demands. They also prevent the use of solid pulleys, ball and some types of roller bearings and clutches unless put on before the shafting is erected.

Clamp couplings are commonly used on lineshafts up to about 4 in. in diameter, although, some special types are used on larger shafts. One of the big advantages of this type lies in that the couplings are easily installed or removed after the shaft is in place, and nothing interferes with installing solid pulleys, collars, clutches, or ball bearings and roller bearings which must be slipped on over the end of the shaft. Clamp couplings are divided longitudinally into two halves which are drawn together by bolts and are usually fitted with a key. They are ribbed for strength and to shield the bolt ends from catching clothing. For real safety it is best to cover them, particularly where they may come in contact with clothing. Most manufacturers provide at an additional charge a special steel shell or cover which entirely encloses the surface and also prevents the coupling from picking up dust or lint. Clamp couplings are usually used on fairly slow speed work. The principal advantage is the ease with which they may be installed or removed. Frequently clamp or compression couplings are used in emergency repair of broken lineshafting.

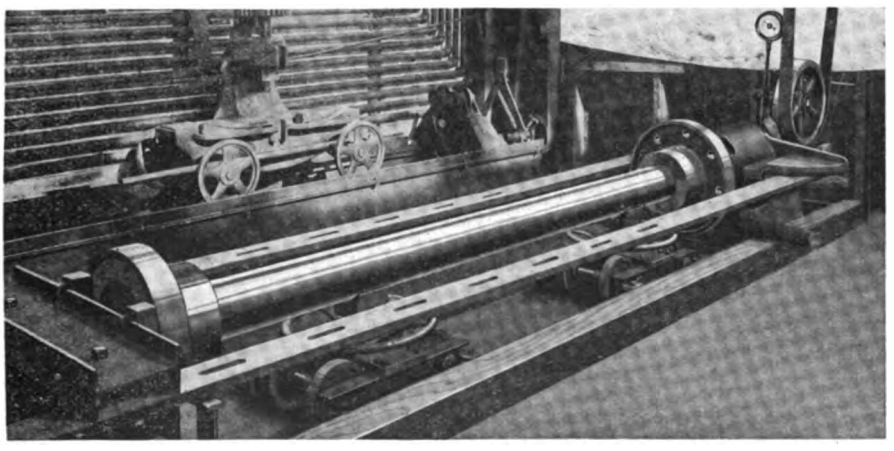
For small lineshafting up to perhaps 1⅛ in. diameter and operating under comparatively light loads, solid sleeve couplings are sometimes used. These are merely a hole through a solid bar and are slipped over the ends of the shaft. The driving is done through set screws although sometimes both keys and set screws are used. A special type of sleeve coupling is illustrated at *G*. Cup-ended hardened pins are driven into the shaft as shown and cut their own cross keyways. These pins may be driven out backwards where it is desired to remove the coupling. These are made for all sizes of shafts up to 5⅛ in. diameter and in reduction sizes. These couplings may be used when the power to be transmitted is well up to the capacity of the shaft and where low first cost is a consideration.



Three common types of couplings.

The male and female flange coupling (upper left) gives good service under severe operating conditions. The disassembled view (above) shows a taper sleeve compression, keyless coupling. The coupling (lower left) is on the order of a clamp coupling except that it is divided into three parts longitudinally and clamps with sufficient compression not to require a key.

Press for forcing flange couplings upon lineshafts.



Types of Compression Couplings and Their Application

Compression couplings like clamp couplings, are used primarily on lineshaft drives of moderate or light-duty capacity where one consideration is the possibility of quickly tearing down a section either to move or to insert or to remove pulleys, ball or roller bearings, clutches and similar attachments. Practically all types of compression couplings depend upon some means of gripping the two ends of the shaft by various methods which impart enough friction to keep the ends from slipping. Several of these types do not rely upon keyways in the shaft. In general these couplings fall into four classes: (1) A double taper sleeve within two flanges which are taper bored to receive the ends of the sleeve. (2) Couplings which comprise two inverted cones within a solid taper sleeve. (3) Taper bearing pieces within two flanges which have tapered keyways to receive these pieces. (4) A tapered spiral sleeve within two flanges which are taper bored to fit sleeve. (*Continued on page 517.*)

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, October, 1923

Goodbye Steam Engine in Rolling Mills!

IT HAS been said that some men change their minds quickly when conditions justify it; others require two, three, four or five years, and others never change their minds. To get new developments into plants operated by the last-named class means that old age or pension time must be abided. The number of this group in the steel industry, however, seems to be very few, for we find the following paragraph in the recent report on developments in steel mill work presented at the Buffalo convention of the Association of Iron and Steel Electrical Engineers.

Operators are realizing more and more that they cannot afford to keep these old steam engines in operation. They are inefficient in their use of steam and require constant attendance and maintenance. It is not an uncommon thing from saving of attendance, maintenance and repairs to more than pay for the fixed charges on the electrical installation, leaving a saving in power consumed as sure profit. The steam-driven mill is slowly but surely being supplanted.

Things must move with certainty in a steel mill and the steam engine has served long and faithfully as a source of power on this basis. But today the success of most operations is measured in operating costs and profits and electric motors on main drives have to their credit sufficient evidence of reliability and savings in operating costs to convince even the pessimists in the older mills and as the report says: "The steam-driven mill is slowly but surely being supplanted."

Can a Turtle Climb a Tree?

MOST of us have a something in our thinking equipment that, when a hard or new job comes along, prompts the overworked expression: "It can't be done" or "It isn't worth while." Yet around every one of us are the results of the work of someone who undertook these "can't-be-done" and "not-worth-while" jobs and has built institutions around them. Men who started as Henry Ford did as a mechanic, as Matthias W. Baldwin did as a machinist, as the Studebaker Brothers did as wagon builders, as Cyrus H. McCormick did in building a mechanical grain cradle, and others whose great works have been shown in the first few pages of each issue of INDUSTRIAL ENGINEER since the first of this year.

These were men of apparently ordinary ability at the start, but endowed with a forward-looking vision and a never-give-up spirit. They tackled a problem of their age and stayed with it. A problem of this day and time in every industrial works is production control from the standpoint of the quality, quantity, cost and profit of the product produced, starting with raw material, machine equipment and operating labor. In this connection the elimination of shutdowns and the waste they represent is a worth-while job for any man whose work calls for an analysis of operating troubles and ways of preventing them.

Right here a little story carries a point that is just as serious as it may appear funny. A father in entertaining his little son with bed-time stories read one about a hungry alligator creeping up behind a turtle, with its jaws wide open and dripping. Just as it was about to swallow the turtle, the turtle gave a spring, ran up a tree and—lived. "But," said the little son, "how could the turtle climb a tree?" "By golly," replied the father, "he just had to," and that settled it.

So if you are up against a tree just climb it and when you get up there thank the alligator.

Experience Is a Good Teacher, But—

WHEN everything is running smoothly in a manufacturing plant and production schedules are easily carried out the inference is that the processes are well laid out and every man is doing his part on the program from the raw product end to the shipping platform. In such cases conditions may be as good as they seem to be until a need for speeding up the output or putting through a rush order is essential and then in order to find the trouble somebody must be taken off his production job to make a detailed investigation. The bigger the plant the more difficult the problem and the longer it takes to change the routine or equipment to fit the new conditions.

In one works employing about 6,500 persons where a survey of department operations was made by the use of graphic records, some startling wastes that had been going on for a long time were discovered. After installing graphic instruments to get a record of the power consumed, the following report was made:

An examination of the records showed that although the machines were started at six-forty o'clock the workmen were very slow in getting started, and it was seven forty-five before this department was running at full load. At ten-thirty work began to slow up, and the power used by the machines decreased so that at twelve o'clock the department was running at only half load. In the afternoon it took the same length of time to get started, and at three-forty the employees began to anticipate quitting time, the work falling off so rapidly that before five o'clock the department was practically idle. The wasted time of the workmen represented a loss of 11.8 per cent of the working time. At the time this record was made there were 460 operatives in this department using power-driven machines. The average rate of pay was $4.68 per nine-hour day. The loss in labor effort shown by this record was 460 × $4.68 × 11.8 per cent=$250 per day, which represents an annual loss of $75,000 per year of 300 days in this department alone.

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The graphic meter is not the cure-all for such conditions but it is an instrument that will provide continuous evidence of conditions, good or bad, as they exist from day to day and furnish comparisons of results that will help to determine where corrective measures or studies of operating conditions should be directed to keep operations and processes up to known standards of efficiency, help workmen to earn their bonuses and enable the plant to earn a maximum return through a continuous and uniform loading of machines, and proper distribution of power and labor costs for each operation while a product is being made. They make it unnecessary to wait during a long period of operation to secure data to justify the original production estimates and guesses.

The graphic instrument has changed the old saying that "experience is a good teacher if it don't cost too much," to this form: "Experience is a good teacher, but it should be graphically recorded."

Electric Heat in Iron and Steel Mills

IN THE report of the electrical development committee presented at the Buffalo (N. Y.) convention of the Association of Iron and Steel Electrical Engineers last month and abstracted in this issue, special reference was made to new uses of electric heat in steel mill operations. One use is particularly interesting because it seems to provide a remedy for roll breakage, a mechanical trouble, and shows how closely electrical and mechanical operations of equipment are related.

Another reference is made to the use of electric steam boilers such as described in the August issue of INDUSTRIAL ENGINEER, page 403. While the electric boiler was first used in Europe on a large scale the applications made in this country during the past year are more novel and on a wider scale than anywhere else in the world today. Where surplus power from fluctuating loads is available these units have proven a very effective means of keeping the load factor constant both in cases where power is purchased and where it is generated. In one plant electric boilers are operated only Sundays and holidays, or about 60 days a year, and have justified their cost on this basis.

Byproducts of Better Methods for Handling Materials

THE OBVIOUS difficulty of prophesying accurately in advance the results from better methods of handling material is one of the biggest difficulties in the way of persuading industrial men to change methods and add equipment, particularly if this involves a considerable expenditure or important revisions of the manufacturing operations. However, if the equipment is properly designed, the results are usually more satisfactory than had been anticipated.

Every improvement in the methods of handling materials in industrial plants should be primarily designed to attain one or more of the following results: a saving in the time of doing the task or in wages of the men involved, lower unit costs as a part of a new production plan, greater reliability or continuity of service. While these are the main results, other advantages, some of which may be totally unexpected, are often found to accrue. Frequently these byproducts are worth-while savings in themselves.

As an example, in one plant it was necessary to truck the trolleys and hooks used on a long monorail carrier back to the starting point. A continuous overhead link conveyor was installed as it was estimated that the saving in truckers' wages would soon repay the installation cost, which it did. Even after an allowance for the necessary maintenance of the conveyor, other savings through decreased maintenance of trucks and the elimination of wear and tear of truck wheels on the floor almost doubled the expected savings.

In another case, a magnet was installed to handle, sort and pile scrap iron and steel because the work was irregular and labor was hard to obtain. As a result, the capacity of the scrap yard was doubled, enough more loose scrap was piled into a car because it was dropped from a height to pack better, to make a freight saving of $20 per car through loading it nearer the minimum shipping weight, a high labor turnover was decreased and a totally unexpected additional saving of about $1,000 per year made due to the elimination of wheelbarrows, forks and other similar tools no longer required, and their maintenance.

Coal unloading and handling devices, such as portable conveyors and other equipment, often save enough in demurrage charges alone to make them a profitable investment in addition to the decreased labor cost of handling and reclaiming coal, which always results.

Hundreds of other examples of byproduct savings such as reduction of accidents, cleaner products, elimination of breakage, and many others could be mentioned in connection with the installation of newer and more modern methods of handling materials, but these examples show the possibilities.

Do You Know So Much That You Can't Learn More?

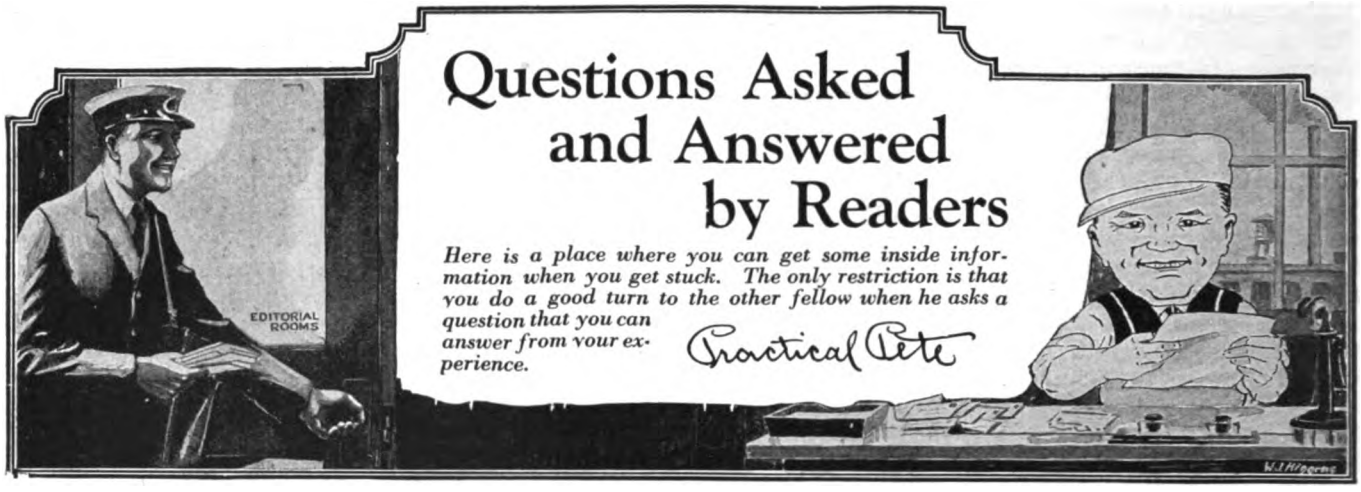
A MAN who has for many years been foreman of the armature winding department of a large repair shop was recently asked if he had read a certain book dealing with motor repair work. "No, I don't pay much attention to such books any more. I used to read them, but I know the work pretty well now," was his reply.

Without a doubt this man has a thorough knowledge of armature repair work, but his remark may explain why he has not risen above the position of foreman, and in all likelihood never will. He feels that he has learned all there is to know about one phase of a subject and is satisfied to stop there. When a person gets in that state of mind he ceases to grow—and when one ceases to grow the doors of Opportunity begin to close.

Those who know the most about any subject are usually the least willing to say that they know all there is to know about it. In the electrical field particularly, new designs and materials, new methods and ways of doing things are continuously being developed. What is common practice today may have been unheard of ten years ago and in many instances will probably be obsolete ten years from now.

Too much self-satisfaction is a dangerous luxury; it is likely to obscure the need for constant study and effort to obtain more knowledge, skill and experience which are essential to real progress.

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Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Testing and Balancing Small Rotors—I wish some reader of INDUSTRIAL ENGINEER would tell me how to test small rotors for all defects which would cause them to run hot. Will someone also tell me what is the best way to balance a rotor?
Vincennes, Ind. R. M.

* * * *

Methods of Storing Spare Motors—I should like very much to have some of the readers of INDUSTRIAL ENGINEER describe the methods which they have devised for storing motors in such manner as to require the least possible floor space. We have over 200 spare motors ranging in size from ¼ hp. to 85 hp. A crane is available and we can pile as high as twenty feet, but floor space is limited and I must use it effectively.
Media, Pa. A. S. H.

* * * *

Commutator Connections of Two-Pole, Compound-Wound Motor—I should like to see a diagram showing how to connect the starting and finishing ends of coils to the commutator of a two-pole, compound-wound motor, which is rated at ¾ hp., 220 volts, 3.7 amp., 1575 r.p.m. The coils have twenty turns of No. 22 s.c.c. wire. There are twenty-four slots, two coils per slot, and forty-eight bars.
Morrero, La. P. D. H.

* * * *

How Do You Explain Operation of Variable-Speed Induction Motor?—I would like some help from readers of INDUSTRIAL ENGINEER on the following questions: (1) In a variable-speed induction motor how does the rotor cut down the speed when the field is revolving at full frequency speed? Please explain briefly the theory. (2) Why are the slots in a Westinghouse 30-hp. rotor on a considerable slant instead of straight across and parallel to the shaft?
Chicago, Ill. V. L.

* * * *

Preventing Corrosion of Iron Storage Battery Racks—I should like to ask your readers what treatment can be given to iron racks for storage batteries which will prevent the spilled acid from attacking the iron. We use the lead type of battery filled with dilute sulphuric acid. We have a large number of storage batteries and recently some iron racks have been constructed. All of these racks were painted with several coats of the best grade of asphaltum black paint but this does not protect the iron when acid is spilled on it, nor does any kind of paint that I have tried.

We have had considerable trouble due to the corrosive effect of the acid forming a substance resembling sand which falls into the jars below. This produces excessive iron in the solution, making a change of acid necessary. I shall appreciate it if anyone can tell me how to overcome this.
Atlanta, Ga. J. B.

* * * *

Path Followed by Current in D. C. Generator—I wish some reader would show by a diagram the commutator connections and the path followed by the current in a direct-current generator which has two poles, 29 segments, 15 slots and 15 coils with a winding pitch of 1 and 4. The machine has two brushes set at 90 deg. I removed a short circuit from the armature of this machine and afterwards drew a diagram to trace the current. Owing to the winding pitch I failed to get the right direction of current flow for each coil. I have had considerable experience in winding d. c. and a. c. machines but this is the first time that I have seen a machine of this design.
Libby, Mont. J. Q. W.

* * * *

Finding Commutator Pitch of Armature Coil with Test Lamp—I should like to have one of our readers answer the following questions: (1) What is the best and quickest method of finding the commutator pitch of an armature coil with a test lamp? (2) What is the quickest method of stripping a partially-closed-slot armature?
Brooklyn, N. Y. H. C.

* * * *

Operating Two-Phase Induction Motor on Three-Phase Circuit—I should like to know if a two-phase induction type or squirrel cage motor can be run on a three-phase circuit, keeping the same speed and pulling the same load. I should like very much to have someone give me a diagram of such a hook-up and state if the two finishing ends of both phases or the start of one phase and the finish of another are hooked together. On what principles will the motor operate?
Chicago, Ill. J. H. B.

Answers Received To Questions Asked

In the September issue of INDUSTRIAL ENGINEER Edward A. Gibbs, in his comments on a case of motor trouble reported by J. H. M., asks for more data and thinks that there is still something unexplained. Now, I have on various occasions seen motors with reversed fields act in the same manner as described by J. H. M. If the motor is started with the rheostat and given time to come up to speed before all resistance is cut out, it will run with the shunt field, but in case power is cut off and the rheostat handle or lever does not come back to the starting position, when power is put on the line again the motor will have no protection, a heavy current will travel through the winding reversing the armature whether it is loaded or not. The same results will be obtained in case the resistance is cut out too quickly on starting. ELZA HERRMANN.
Middleport, Ohio.

* * * *

Preventing Corrosion of Copper—Will someone please tell me how I can prevent the corrosion of copper parts of equipment that is located in a chemical plant. I have tried everything I can think of, but without success.
Charleston, W. Va. E. B. G.

In the July issue, E. B. G. asks how to prevent the corrosion of copper parts by acid fumes. Copper parts that do not have to be handled often may be covered with a coating of a good grade of vaseline thinned somewhat with gasoline. Parts that are subject to much handling should, however, be coated with orange shellac. A fresh coat should be put on whenever signs of corrosion appear on the copper. I have found that these two coatings will withstand most acid fumes. J. H. GALLANT.
Belleville, Ont., Can.

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Removing Insulation from Enameled Wire—I should like to know if any of your readers know of a quick method of removing enamel from magnet wire, other than scraping with a knife. I find it takes a great deal of time for this operation in winding a motor and I would be very grateful if someone can tell me of an easier method.
Avenel, N. J. J. U.

Regarding the query of J. U., in the August issue concerning a quick method of removing enamel from magnet wire, from my experience I have found that the quickest and safest method is to use very fine emery cloth which has been well soaked in alcohol or turpentine.

Both alcohol and turpentine have a very marked tendency to soften the insulating enamel, thus making possible a very clean removal without injury to the conductor itself.

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

In the August issue, J. U., asked if there is a quicker way of taking enamel insulation off of fine wire than by scraping. We have found that by using a fine grade of sandpaper, that is, finer than No. 1, the enamel can be removed cleanly and quickly. The sandpaper is most easily handled by cutting it into strips about 2 in. or 3 in. long and 1 in. wide, and folding it. The wire is then put in the fold and the enamel sanded off. Too coarse a grade of paper will break fine wire before the enamel comes off. We have tried acids and chemicals for removing the enamel but have found nothing of this sort that is safe to use on armatures, especially around commutators. GEORGE D. RINGNESS.

Peoria, Ill.

* * * *

With reference to the question asked by J. U. in the August issue, the coating on enameled wire may be removed very satisfactorily by the use of "Oakite," a compound made by the Oakley Chemical Company of New York, N. Y. A few ounces of Oakite are used to a gallon of water and the solution should be kept near the boiling point for quicker removal. The ends of coils can be suspended in the solution for a few minutes or the wires may be reeled through the solution slowly if the entire wire is to be cleaned. The solution must be washed off in hot water and the wire will then retain enough heat to dry itself.

This company's "Plater's Cleaner" must be used for removing some classes of insulation. Special problems should be referred to the company for their recommendations as to the exact concentrations to use.

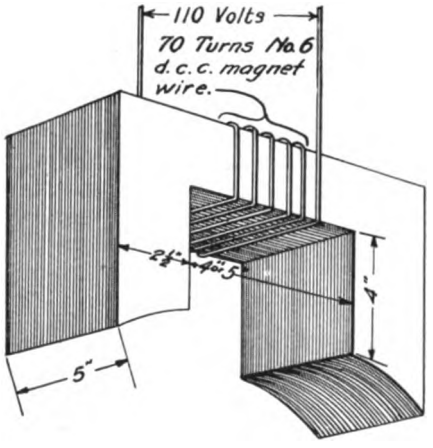
The writer uses a large tank of this solution for removing varnish and oil from motor stators after these have been stripped. The stator comes out in 15 min. as clean as a new motor. The cost of this method of cleaning is 75 per cent lower than that of scraping and finishing with gasoline and gives a far better job. The motors are rinsed off with cold water, but enough heat remains in the iron to dry the stator quickly.

J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Ore Company,
East St. Louis, Ill.

* * * *

Design of a Growler for Testing Armatures—I wish some of the readers of INDUSTRIAL ENGINEER would tell me how many turns and what size wire to put on a laminated core in order to make a growler for testing armatures up to 50 hp. in size. This core is 8½ in. x 4 in. x 4 in., and has a 1¼-in. slot cut into it. If necessary I could make the core longer. Alternating current of 110 or 220 volts is available for operating the growler.
Canton, Ohio. R. M.

In answer to the question by R. M., in the August issue in regard to the design of a growler for testing armatures up to 50 hp., I wish to submit the accompanying drawing. This drawing shows the construction de-



Design of growler for testing armatures up to 50-hp. in size.

tails of a growler, consisting of a laminated iron core wound with 70 turns of No. 6 d. c. c. wire, which I have made up for my own use and have found very satisfactory for testing railway, elevator and crane motor armatures in our repair shop. I hope this information will be helpful to R. M. and to our many other readers. U. O. MISNER.

Pioneer Electric Co.,
Richmond, Calif.

* * * *

In reply to R. M.'s question in the August issue, I am using 4¾ lb. of No. 13 magnet wire, single cotton and enamel insulation, on my testing growler and have found it very satisfactory as it will do all that I ask of it and I have found it suitable also for baking small armatures.

Los Angeles, Calif. J. WOLFE.

* * * *

Locating Trouble in Wiring Circuit—I would appreciate suggestions from readers on the best scheme for testing B X wiring circuits for troubles such as short circuits and grounds, which does not require taking out switches and receptacles or dropping of canopies of lighting fixtures.
Brooklyn, N. Y. H. F.

In answer to the question asked by H. F. in the April issue on locating trouble in wiring circuits, once in a while a good wireman will find trouble on a BX installation when he tests it out at the end of a job. In such cases I trace this out as follows: If both fuses are blown in the service cutout it is probably due to a short before the wires reach the branch cutout fuses, as these latter are smaller and would blow first if the trouble was on a branch line. If one of the service cutout fuses is blown it means there is a ground on that line before it reaches a branch cutout, but if one or more fuses are blown on the branch cutout the ground is inside that point and outside any other fuse that may be still further in, in the line. If the trouble is found to be a ground, the easiest way to locate it is to loosen the BX squeeze fitting and pull out the armored section so as to open up the ground return. It is then easy to find out on which side of the open ground the ground is located. This can be done where the BX drops to the cellar conduit or any other accessible place and by following this out you can tell in which branch it is located.

If you cannot get power you have an open and you will have to try in about the center of the feeders. If you get power there the open is farther away from the service. The cause of most of the opens in BX work lies in the way that the wires are handled during the time that the armor is being cut off and afterwards when the joints are being made. Most of the grounds are found under switch and receptacle plates where the wires go under the screws and the ends touch the plates.

Before testing out for an open in the wiring it is advisable to see that all the fuses are in good condition, as the trouble may be due to a blown fuse from a ground.

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A temporary way to fix a circuit with a ground is to reverse the wires at the service cutout, thus putting the ground wire on the grounded side of the system. They must not, however, be left this way permanently because if an open should develop in the ground wire and a fuse blow in the grounded side, a person would get a shock upon touching the piping system. R. M. BEECHER.

Buffalo, N. Y.

* * * *

Rewinding Single-Phase Motor—I have a single-phase Menominee motor that has a main winding of 29 turns of No. 19 wire with two wires in parallel in slots 1 and 7. There are 48 turns in slots 2 and 6 and 49 turns in slots 3 and 5. This is a 4-pole machine.

The starting winding has 12 turns of No. 25 wire in slots 1 and 7; 20 turns in slots 2 and 6, and 20 turns in slots 3 and 5. What I want to know is whether or not this motor can be wound with a single wire and what size will be required to replace the two No. 19 size in parallel. The motor has 24 slots and the nameplate shows 110 volts, 3.8 amp. 1/6 hp., 1750 r.p.m. I have just rewound one of these motors with a single No. 19 wire and it seems to run all right.

Sartell, Minn. L. S.

In regard to the question by L. S. about rewinding a 1/6-hp. 110-volt, 1760-r.p.m. Menominee motor with one wire instead of two in parallel, No. 19 B. W. G. wire has an area of 1,764 circ. mil. Two in parallel make a total of 3,528 circ. mil. No. 16 B. W. G. wire has an area of 4,225 circ. mil and No. 17 an area of 3,364 circ. mil. In order to work the copper as low as possible, it would be best to use No. 16 wire; using the same number of turns the motor will run a little cooler.

L. S. can also wind the running winding with one No. 19, putting ninety-six turns in slots 2 and 6 and ninety-eight turns in slots 3 and 5. For 110 volts connect the winding in parallel; for 220 volts connect it in series.

For the starting winding put twenty-four turns of one No. 28 wire in slots 1 and 7, forty turns in slots 2 and 6 and forty turns in slots 3 and 5. Connect two coils in parallel for 110 volts or in series for 220 volts, the same as for the running winding. P. P. SCRIBAUTE.

San Francisco, Calif.

* * * *

Answering the question by L. S. in the July issue of INDUSTRIAL ENGINEER, concerning the rewinding of a single-phase motor, there is no reason why the motor as rewound should not operate normally in that it is free from distress and with electrical and magnetic quantities well within the limits prescribed by good design and practice. However, it is somewhat wasteful of material because more iron is in use than is needed to carry the flux set up by the new winding. According to the new winding the motor now has one-half the cross-section of copper and twice the ohmic resistance that it had originally. Therefore, the current input should be one-half its former value, and it is to be expected that the rating will be one-half of what it was at first, or 1/12 hp.

If there is sufficient slot space it is possible to rewind this motor with a single wire of twice the cross-section, or, since the area of a No. 19 B. & S. gage wire is 1,288 circ. mil, the new wire size will be 2 × 1,288, or 2,576 circ. mil, or a No. 16 wire. But, since the surface area of a single wire of twice the cross-sectional area will be less than that of two wires of one-half the sectional area, the full-load temperature of the machine will be somewhat higher than it was with the two wires in parallel. Also, it might not be possible to use the same number of turns of the larger wire due to the fact that the curvature of the larger wire is less than the curvature of the smaller wire, and consequently, not as economical in the use of slot space.

If practical results are to be the criterion of our design, this winding will give the performance desired.

Chief Electrician, D. L. WAYNE.
Prairie View State Normal College,
Prairie View, Tex.

* * * *

Size of Equalizer Cable—What is the ratio of the size of an equalizer cable to the positive cable of a 100-kw. d. c. generator? Suppose two generators, one of 100-kw. and the other of 500 kw. are to be used together. What would be the size of the two equalizer cables and how is this size determined?

Lima, Ohio. J. E. B.

In reply to J. E. B.'s question in the April issue of INDUSTRIAL ENGINEER, an equalizer cable is of the same area in circ. mils as the positive cable. Two machines of different ratings may be operated in parallel provided the voltages are the same and the resistances of the series fields are made inversely proportional to the current capacity of the two machines to be connected. Each machine will then take load in proportion to its capacity. The series field can be adjusted by adding extra turns of wire to this circuit, as required. The area of the equalizer cable connecting these machines should be as large as the positive cable of the smaller machine. The circuit breakers on the smaller machine should be set at the rating of this machine in order to prevent overload and damage.

Americus, Ga. B. BELCHER.

* * * *

The following will answer J. E. B.'s question in the April issue, regarding the size of equalizer cable. Although the current carried by the equalizer cable depends upon the compounding and regulating characteristics of the two machines which are operated in parallel, and may not be very large, it is important for the sake of stable operation that the equalizer cable form a path of very low resistance. Therefore, the equalizer cable should, in this case, be just as large as the positive cable of the 100-kw. generator; if it were larger no harm would be done. If the 100-kw. generator is to be replaced later by a larger generator, the equalizer cable should also be replaced by one as large as the positive cable of the smaller of the two generators in parallel.

Des Moines, Iowa. W. E. PAULSEN.

* * * *

Answering the question of J. E. B. in the April issue, regarding the proper size of equalizer cable: The function of the equalizer cable is to keep the drop across the series fields of two or more compound-wound generators the same, so that one of the machines will not have too strong a field and tend to "hog the load." The resistance of the equalizer cable should be low enough to keep the potential at the series field terminals of the two machines practically the same, and, therefore, the size of wire might have to be larger if the machines were some distance apart than if they were close together. As J. E. B. does not give the voltage of the two machines there is no way of knowing the normal current through the series fields or the probable drop across them. One rule, however, is to make the wire large enough to carry safely one-half of the full current of one of the generators. When the two generators are of different size this would mean that the load of the larger one would have to be considered when figuring out the proper size of equalizer.

It is not often that two machines of so great difference in size are worked together, as their character-

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istics have to be considerably alike. Also the resistances of their series fields should be inversely as the amount of current passing through them in order for the drop across the two fields to be the same.

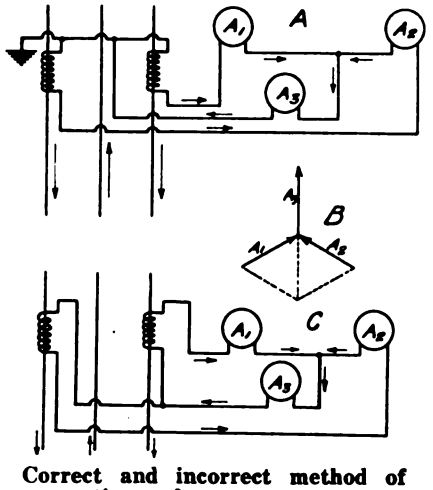
Westfield, N. J. G. H. McKELWAY.

* * * *

Ammeters Connected for Three-Phase, Three-wire Circuits—I wish some reader of INDUSTRIAL ENGINEER would give me a wiring diagram of three ammeters used on a three-phase, three-wire circuit, using only two current transformers, and explain how current passes through each meter.

Haledon, N. J. G. Z.

Answering the question asked by G. Z. in the August issue as to how ammeters should be connected for a three-phase, three-wire circuit, in the illustration *A* shows the diagram of the connections. It should be noted that ammeter A_3 is in the return circuit from ammeters A_1 and A_2.



Correct and incorrect method of connecting three ammeters on three-phase circuit.

The vectorial relation of the circuits is shown in *B*. It will be noted that the three currents are fundamentally at 120 deg. to each other; hence the resultant of A_1 and A_2 will equal A_3. This reasoning applies whether the currents are balanced or unbalanced in A_1 and A_2. Should the connections of one transformer be reversed, for instance that for A_1, the current shown by A_3 will be $\sqrt{3}$ times the current in A_1 or in A_2 if balanced. In other words, with 5 amp. in A_1 or A_2, A_3 would show 8.66 amp.

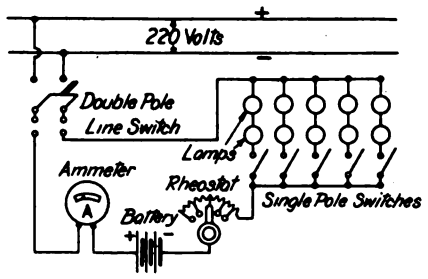
C. OTTO VON DANNENBERG.

New York, N. Y.

* * * *

Charging Storage Battery—I would like to charge the storage batteries in our plant from a 220-volt d. c. exciter circuit of our 2,300-volt a. c. generators. If some readers will show a diagram of connections and a practical method for reducing the voltage, I will appreciate it.

Amenia, N. Dak. J. P. C.



Method of charging storage battery from 220-volt circuit.

Regarding J. P. C.'s query on battery charging, the diagram shows a simple method that can be used successfully on d. c. circuits for charging small cells.

The current is controlled by a lamp bank consisting of five sets of lamps in parallel with two 110-volt lamps in series per set. By using various sized lamps a very flexible control of voltage is obtained, with still finer adjustments made by the rheostat. Using 110-watt lamps and with all single-pole switches in, approximately five amp. will be obtained. To reduce current cut out sets of lamps or reduce size of lamps used.

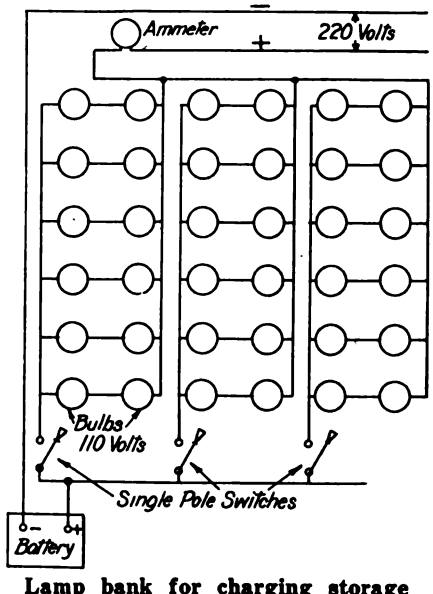
J. B. RAKOSKE.

Detroit, Mich.

* * * *

In answer to J. P. C.'s request in the March issue of INDUSTRIAL ENGINEER for a method of charging storage batteries from a 220-volt exciter circuit, I am enclosing a diagram which I think will be satisfactory. This diagram shows only a few lamps, but as many may be used as are necessary to get the right amperage through the battery. If there are several batteries connect them in series.

This hook-up was used in a shop



Lamp bank for charging storage batteries from 220-volt line.

where I worked, and proved very satisfactory for charging two and three batteries at a time. The only difference is that we used a 110-volt d. c. system instead of 220 volts, and, of course, had one lamp in the place of two. I think the same results would be obtained if connected as shown.

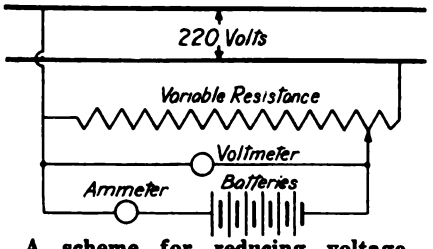
By the use of the single-pole switches at the bottom of the board as shown, the resistance can be controlled as desired. I might also mention that we used 100-watt carbon lamps.

D. S.

Providence, R. I.

* * * *

The accompanying diagram shows an arrangement that can be used to charge storage batteries as mentioned by J. P. C. By this method the voltage can be reduced to any desired volume.



A scheme for reducing voltage when charging storage batteries.

H. H. DUNCAN.

Brooklyn, N. Y.

* * * *

In the March number of the INDUSTRIAL ENGINEER, J. P. C. asks how to charge a storage battery from a 220-volt exciter. He does not mention the voltage of the battery, but if it is much less than that of the exciter, he will have to put sufficient resistance in series with the circuit to cut the flow of current down to a safe amount, that is, to the proper charging rate of the battery. If he should desire to charge the battery at the same time that the generator is being used as an exciter, it would be best to have an adjustable resistance in order to control the charging current, because then the field circuit of the generator, and consequently its potential, could not be altered.

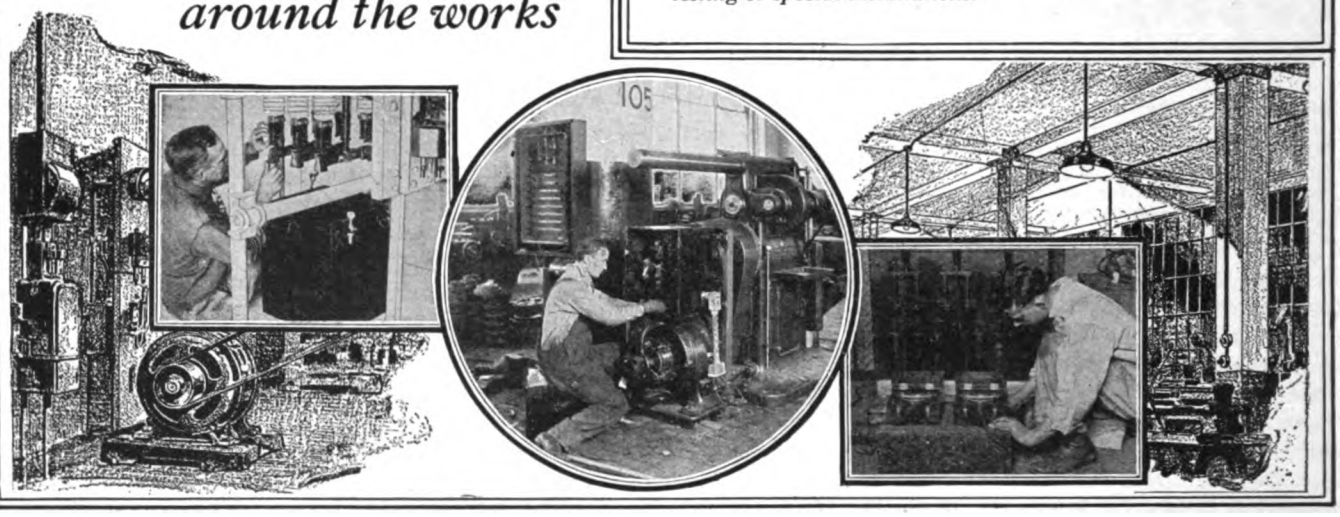
To charge, the positive side of the generator should be connected to the positive side of the battery through the resistance and also through a switch and either a fuse or circuit breaker. Then the amount of current supplied to the battery can be controlled by altering either the amount of the resistance or the field strength of the generator.

Westfield, N. J. G. H. McKELWAY.

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SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

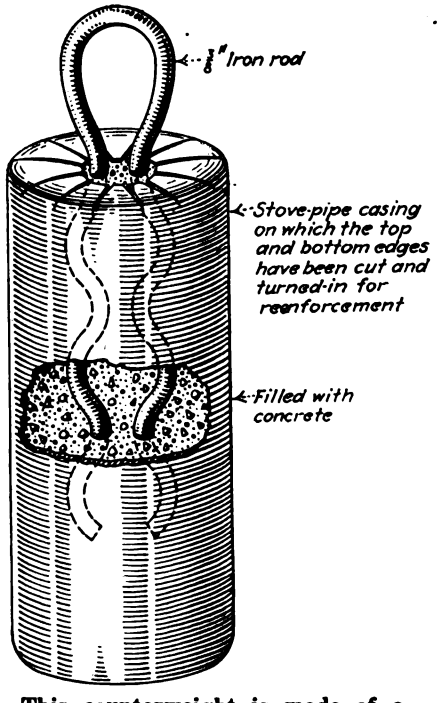


A Simple and Easy Way to Make Inexpensive Counterweights

THE type of counterweight used for the safety gates at the entrance to car lifts in a large garage may be employed in various places. Each of these weights is a concrete cylinder cast in a sheet-metal enclosure. In this case the sheet metal used was a length of 6-in. black-iron stove pipe. To provide a means of attaching the cables, ⅜-in. iron rods were bent and placed in the cylinder before the concrete was poured. The edges of the casing were turned in to reinforce the cylinder and keep the concrete from crumbling at those points where the weights most frequently strike.

With this method of casting the weight to suit the requirements, it is possible to vary the diameter and length so that a weight exactly suited to the needs is obtained without delay or special facilities for casting and cutting off or adding extra material. Materials for making the weight should be weighed in the dry state as this is the condition that obtains when the concrete is hard.

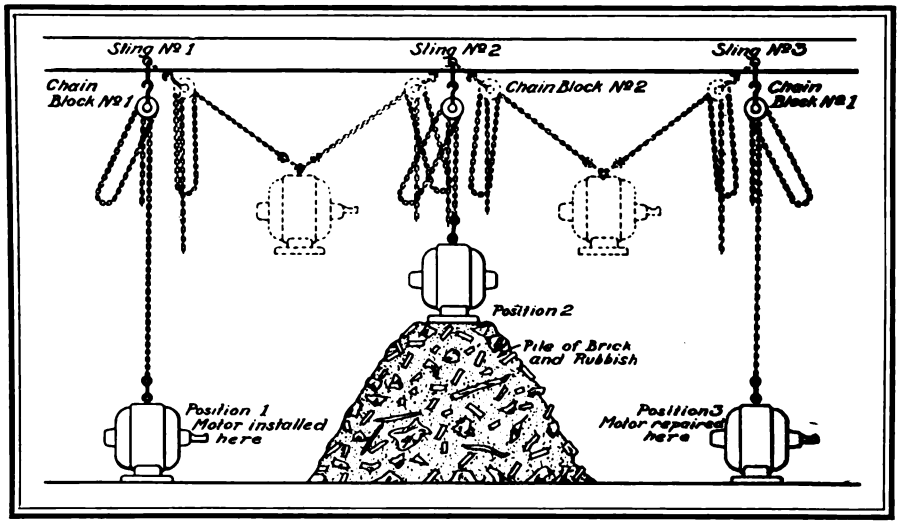
Washington, D. C. G. A. LUERS.



This counterweight is made of a piece of stove pipe filled with concrete.

Easy Method of Moving a Motor Over an Obstacle

SOME time ago it became necessary to repair a motor in the shop. On account of construction work going on at the time, a large pile of bricks, broken concrete and other rubbish lay between the place where the motor was installed and the repair section. Two chain blocks were available and a method which may be of interest to the readers of INDUSTRIAL ENGINEER was devised of using them to move the motor from its original location to the repair section. As shown in the illustration, three slings for supporting the chain blocks were fastened to a roof truss directly over the motor, over the pile of rubbish, and over the repair section, respectively. The chain blocks were first suspended from slings Nos. 1 and 2. The motor was then raised several feet from the floor by No. 1 chain block, after which the hook of No. 2 chain block was placed in the lifting ring of the motor alongside of the hook of No. 1.



By means of two chain blocks the motor was first placed on the pile of rubbish and then transferred to the desired location.

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As the chain of No. 1 block was slackened off, the chain of No. 2 was tightened with the result that the motor was easily deposited in position 2, on top of the rubbish pile.

Chain block No. 1 was then removed and suspended from sling No. 3 and its hook placed in the lifting ring of the motor, as before. As the chain of No. 2 block was slackened, the chain of No. 1 was tightened so that the motor finally was suspended several feet from the floor, on the chain of No. 1 block. The hook of No. 2 block was then removed and the motor lowered to position 3, where we could do the necessary repair work more easily than would be possible if the motor were kept in its original position.

This same method of handling was used later to place a heavy rheostat on its support over a rather deep switchboard. HENRY MULFORD.

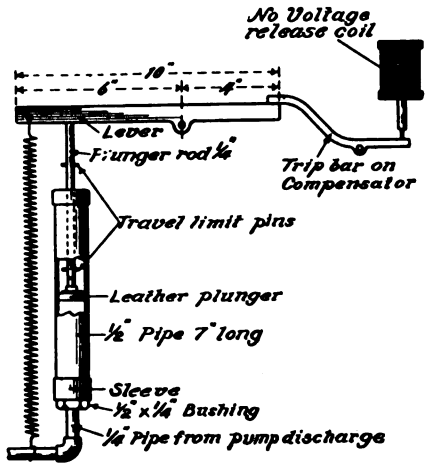
Electrician,
Patchogue Electric Light Co.
Patchogue, N. Y.

Lighting up of Signal Lamp Indicates When the Pump Accidentally Stops

IN THE January, 1923, issue of INDUSTRIAL ENGINEER, Mr. A. J. Dixon described on page 57, under above heading, a device for indicating when a centrifugal pump for any reason ceases to deliver water. A centrifugal pump in our mill lost its suction one day and when the watchman, who makes his rounds every half hour, noticed the trouble the pump was hot and smoking. The motor was still running, but no water was being delivered. All of the brass inside of the pump was burned out and we had to get along without the pump for three days.

To prevent this happening again, I made a device similar to the one described by Mr. Dixon except that instead of using a red lamp I connected the no-voltage coil to the bar supporting the water bucket. Water ran into the bucket through a small pipe and out again through a smaller hole in the bottom of the bucket. So long as the pump delivered water the bucket held the arm down and made the contact for the no-voltage relay. When the water stopped flowing the bucket soon became empty and the arm rose, breaking the circuit in the relay and thus stopping the motor.

Later I made another device which I feel is more satisfactory, for stopping the motor. This device is simple and, as shown in the illustration, consists of a 10-in. lever which is pivoted slightly off center. One end of the lever is raised by a plunger rod in a small cylinder connected to the discharge side of the centrifugal pump, while the other end is in contact with the trip bar of the compensator. As will be seen, the cylinder was made of a piece of ½-in. pipe 7 in. long. A piece of seamless brass tubing would probably make a better cylinder, but I did not have any at that time. The pipe was filed smooth on the inside and the ends fitted with sleeves. A ½-in. x ¼-in. bushing was screwed into one sleeve in order



When the plunger rod goes down through failure of water pressure the lever drops and operates trip.

to connect the cylinder at the bottom to the ¼-in. pipe leading from the pump. The sleeve on the upper end of the cylinder was cut in two and then filled with babbitt and bored to receive the ¼-in. plunger rod which was threaded at the lower end. The plunger was made of leather and was held on the plunger rod by a nut.

I found it advisable to fasten a small piece of sheet iron on each side of the lever to serve as a guide for the plunger rod and keep it from slipping off. Also, a spring or weight should be placed on the inner or plunger end of the lever so that when the plunger rod drops the lever will be sure to follow it. Two small pins were put through the rod, one inside the cylinder and the other outside, to limit its travel.

In operation, so long as water pressure is on, the plunger rod holds the inner end of the lever up so that the trip bar is also held up. When the pressure goes off, however, the plunger rod drops down and allows the lever to fall, thus operating the trip and stopping the motor. This device is positive in its action and has given satisfactory and reliable service. F. G. BONN.

Hammond, B. C., Canada.

Practical Points on The Operation of Electric Steam Boilers

IN THE August issue of INDUSTRIAL ENGINEER I read with interest the article on electric steam boilers by P. H. Falter. There are, however, some details not mentioned in this article regarding the operation of these boilers on which I would like to get more information.

What percentage of moisture does the steam carry on leaving the boiler while operating with a high water level?

On page 404 in the first column the following comment is made: "No chemicals should be added to the feed water for electric boilers." Are the chemicals ordinarily used in boiler feed water detrimental to the electric boiler?

Does scale form on the electrodes and if so, what effect has it and how can it be prevented or removed?

I understand that superheaters and automatic electric control are being developed for electric boilers. How do they operate?

Smooth Rock Falls, Ontario, Canada. W. A. PLANT.

* * * *

NOTE: The above questions were submitted to Mr. Falter and his reply follows.—EDITORS.

The percentage of moisture in steam from electric boilers varies according to the design of boiler employed and to a certain extent to the character of the water. Where very dirty waters are used, there may be a tendency to foam as there would be if such water were boiled with heat from any other source and the percentage of moisture carried over would then be higher. We find, in actual practice, that the percentage of moisture carried over in electric steam has never reached 5 per cent, and as electric steam can only be used for heating purposes, since it would manifestly be absurd to use it for power purposes, the amount of moisture is not objectionable, because the electric boiler is generally placed close to the apparatus in which the heat from the steam is used. Superheaters are, therefore, not necessary unless they would be necessary for any other style of boiler in transmitting the steam unusually long distances.

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An attempt has been made to superheat electric steam with electric steam, the principle in brief being to have an electric boiler generate steam at a high pressure and pass it into a heat interchanger through the coils of which part of the electrically-produced steam is admitted under low pressure through a pressure-reducing valve. The low-pressure steam, therefore, takes up heat from the higher-pressure steam and is thus superheated. Manifestly, no great degree of superheating can be obtained in this manner so that where superheating is required, it should be provided either through the ordinary form of superheater or in a separate chamber independently heated electrically to give the desired degree of superheating.

Generally speaking, a feed water which is satisfactory in a fuel-fired boiler may be used in an electrode-type boiler. What I meant by saying that no chemicals should be added to the feed water for electric boilers is that no attempt should be made to hold the resistivity of the water in the boiler at any desired point by the introduction of chemicals. The resistivity of electric boiler feed water or rather the water after it has entered the electric boiler can be well enough controlled by the proper methods of operating an electric boiler of this type.

European practice some years ago, and even to this day to a certain extent, requires the use of a "doper" with which to doctor the water within a boiler to hold its resistivity at some predetermined figure, but American and Canadian practice has from the very beginning discouraged doping in any form, since as already stated, the boiler can be operated satisfactorily after it has been properly designed for a water in a given district. Even uncontaminated or untreated waters vary greatly in different parts of the country, so that electric boilers must be properly designed to suit the water in any given locality.

The qualities of the water also have much to do with the amount of scaling of electrodes and boiler shell, just as in the case of any other kind of boilers, but scales can be removed much more readily from the electric boiler than from an ordinary tubular, fuel-fired boiler. Ordinarily the entire head of a boiler can be removed and, except for the smallest sizes, a man can get right down into the boiler shell with a hammer and break scale loose. The electrodes are generally attached to the head of the boiler so that when the head is removed the electrodes are in full view and readily accessible for removal of scale. The effect of scale on electrodes is generally to insulate them so that they will carry less and less current, thus reducing the capacity of the boiler in time and requiring the removal of the scale in order to put the boiler back into satisfactory, full-load operating condition.

As to automatic control of boilers, the writer personally, and also his company, has done much to provide for almost any given requirement. We have worked out and applied for patents on several types of control. The two most important of these are what might be called mechanical control, in which the electrodes are moved, and pneumatic control, in which the water level is changed either upward or downward. Most so-called electric controls are unsatisfactory in that they only permit definitely increasing the load of a boiler, but do not permit definitely and quickly decreasing the load. To decrease a load on an electric boiler either the electrodes must be withdrawn from the water a sufficient extent, or the water must be withdrawn from the electrodes; that is, the water level must be changed.

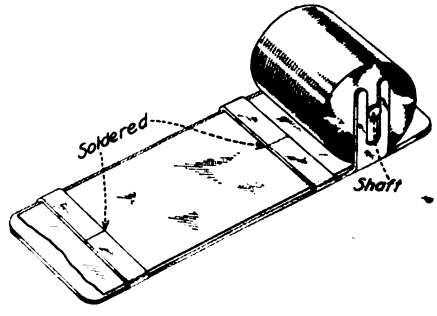
It is not desirable to waste the hot water in a boiler and for this reason our pneumatic method was perfected. It is now possible to change the load which a boiler carries at any reasonable rate and thus to cause an electric boiler to take on surplus power and to automatically release such power when a mill again requires it, thus keeping the load factor of a system at or very near 100 per cent. This is very important since load factors often are as low as 30 per cent, as in steel mills, and are seldom much above 80 per cent unless we are considering electrolytic loads. Power is frequently bought to meet a maximum demand, but very few loads are constant. Therefore, anything that can be done with the power between the normal load factor and a 100 per cent load factor, reduces the cost of power paid for but not used. Wherever there is a use for steam or even hot water the electric boiler supplies an excellent way of using such surplus power to advantage.

Controls may be effected by a totalizing watt-meter, by a steam gauge or by the changes in frequency of a system, in any of these cases, however, causing the electric boiler to automatically take on or to release power, as the case may be, thus maintaining a load factor very close to 100 per cent. Where it is only necessary to maintain a steam pressure irrespective of power supply, a very simple method has been developed for causing the electric boiler to automatically follow the steam demand.

P. H. FALTER.
Electric Furnace Construction Co., Philadelphia, Pa.

How to Make a Holder for Desk Memorandum Roll Paper

MEMORANDUM pads in roll form are handy for desk use, as the paper can be torn off in any desired length, according to the extent of the memorandum. Rolls of paper for use in a holder are obtainable in widths of 4 in. to 6 in. and the outside diameter of the roll is about 5 in. The holder is formed from sheet metal and can be made as



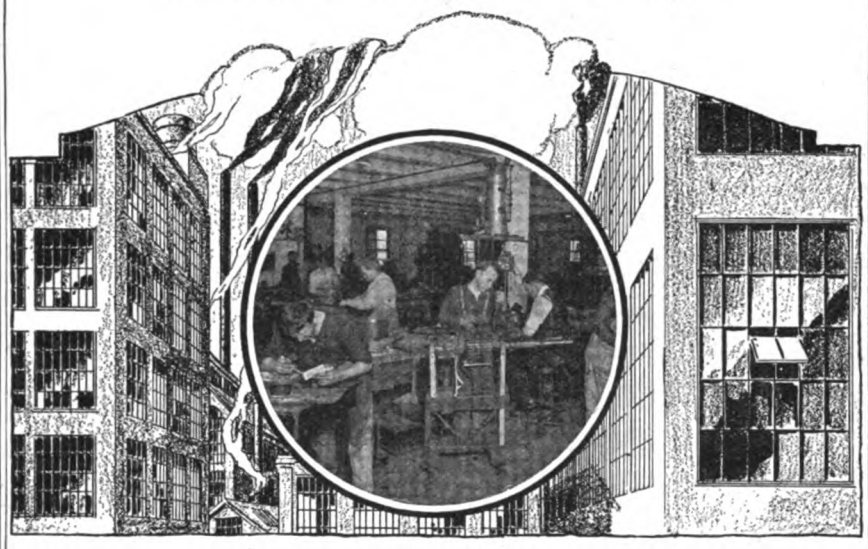
Paper is torn off according to length of memorandum written.

elaborate as desired. For a simple holder the design shown in the accompanying illustration is recommended as a sturdy and durable type. A large number of these have been made for use in the offices of a local machinery plant. The holder is in one piece, cut from sheet brass of the shape shown in the developed plan. It is then bent and the strips across the holder are joined with solder. The vertical parts serve as guides for the shaft supporting the roll of paper. The rear cross strip is beveled as a cutter to facilitate tearing off the memorandum. In the case of the holders made for office use, the owner's initials were stamped on the cutting strip and the holder was nickel plated, thus making a neat individual accessory for each desk worker.

G. A. LUERS.
Washington, D. C.

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In the Repair Shop



This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

How to Make a Simple Washer Cutter for Use At the Bench

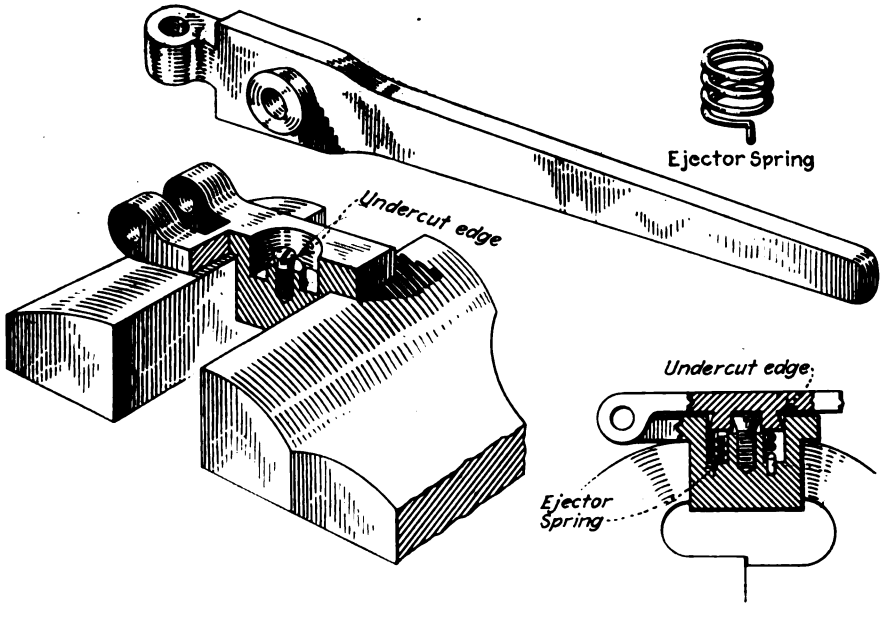
THE SPECIAL cutting fixture shown in the accompanying sketch can be used for cutting various sizes of leather, composition rubber, fiber and sheet-metal washers. Every maintenance man knows how frequently these washers are required. With a cutter such as this a number of each size may be made up in advance.

Differing from the usual types, this fixture has no separate dies nor does it require the use of a hammer or press to operate it. The simple operation of pressing the lever makes a finished washer in this one movement. The fixture as illustrated is held in the jaws of a vise and an extended hand lever furnishes the means for obtaining a heavy pressure at the cutting edges of the die.

The lower section is a steel forging, with a block or lug for the vise jaws. The die recess is sunk into the forging and has a tapped hole for a center punch to cut the hole in the washer. The spring serves to eject the cut washer. The upper section of the cutter embodies a handle, extended cutting edge and hinged member to correspond to the lower section. The cutters are tempered to hold the cutting edges. Sizes are not shown in the sketch, as these depend upon the required washer sizes.

Washington, D. C. G. A. LUERS.

Washers may be easily cut from fiber or other material with this device.



How Arc Welding Cuts Repair Costs on Worn Flasks in the Foundry

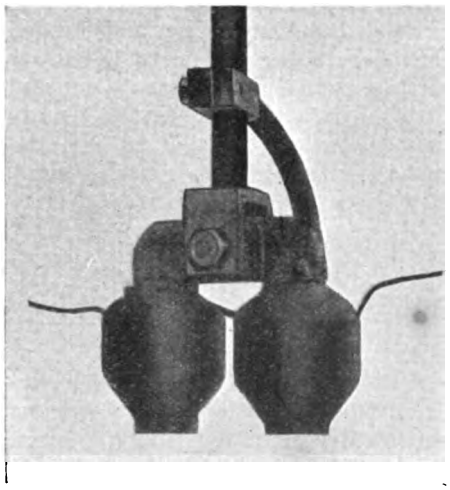
AN INTERESTING and successful application of arc welding in foundry practice is that of repairing worn flasks. The accompanying illustration shows a pile of flasks which have been repaired by the arc with the exception of the one in the foreground. The upper malleable iron lug on this flask shows that the hole in it has been worn until the pin on the other half of the flask will not fit in it tightly enough to hold the parts in sufficiently good alignment. The practice in the past when making repairs has been to ream out the hole to 7/8 in. and then press in a 5/8 in. bushing. When the bushing wore too large it was replaced with a new bushing.

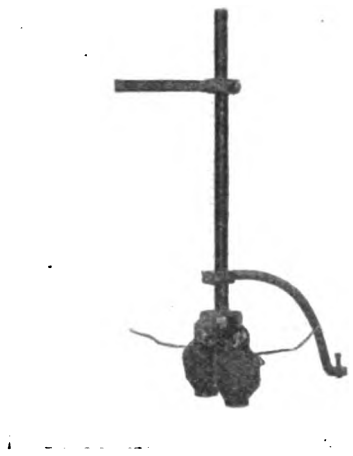
The new method of repair, however, is less expensive and much more satisfactory. The practice now is to ream out the hole to 7/8 in. and then fill the hole completely using the metallic-electrode, arc welding process. A piece of copper is placed under the hole and the welding is made by using about 175 amp. and



Pile of flasks repaired by the arc welding process as described in the accompanying item.

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These two photographs show a close-up view of the magnet foot (at the left) and a complete view of the magnetic "old man."

5/32 in. welding wire. About three minutes are required to weld a hole.

When these holes are again worn oversize it is not necessary to ream them out before the welding operation. The time required to weld a hole is then reduced to about two minutes. The cost of welding each hole as originally drilled to 7/8 in. diameter is about as follows:

Labor at 70 cents per hr.....	$0.035
Welding wire at 8 cents per lb...	.016
Electric power at 3 cents a kw-hr.	.013
	$0.064

The question naturally arises as to why it is necessary to drill a 7/8-in. hole in the casting when only a 5/8-in. hole is required for the pin on the flask. The reason for this is that there will be a layer of hard, chilled, high-carbon cast steel about 1/16 in. thick in the region where the deposited metal unites with the casting; therefore it is necessary to have the original hole 1/4 in. larger in diameter than the final hole so that no difficulty will be experienced in drilling the final hole through the deposited metal.

A. M. CANDY.
General Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Drilling Holes on Surface of Large Cylinder with a Magnetic "Old Man"

IT BECAME necessary when making some repairs, to drill about 1,500 holes (5/16 in. or 3/8 in.) in some 1¼-in. boiler plate shells 19 ft. in diameter and 65 ft. long. A portable electric drill was available, but the difficulty of applying the pressure is readily realized. The magnetic "old man" illustrated in the accompanying sketches and photographs made the operation a most simple one. The spherical shape of the ends of the shell required the planes of the faces of the magnet to be adjustable. In addition it was designed to be built of easily available material.

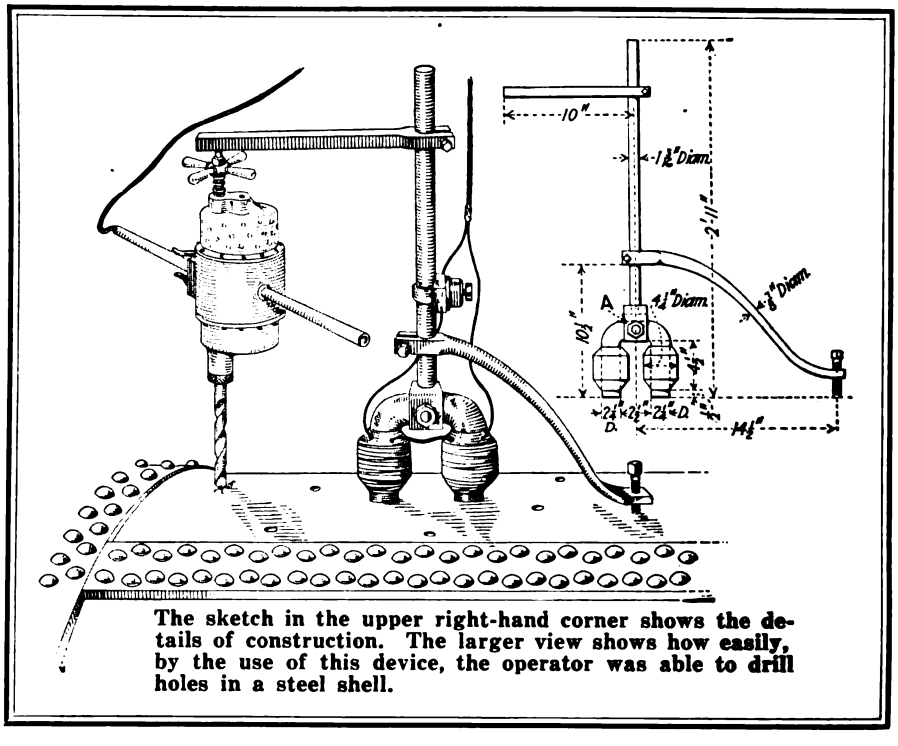
Of course, the first hole might be forced through the shell and then the ordinary type of "old man" bolted on. That, however, would have required considerably more time to move and adjust into position than did this which merely required turning the current off, moving into position and turning the current on again.

A horseshoe magnet was forged to the approximate dimensions shown in two similar parts, from 2¼ in. round iron; this was machined and hinged at *A* to maintain a full cross-section. The pole faces of the core are machined. Each half of the magnet is wound with 750 turns of No. 16 double cotton-covered copper wire and connected in series to form one north and one south pole. The cores were wrapped with two layers of varnished cambric and the coils covered with a wrapping of cotton tape, impregnated by immersion and later varnished. A yoke of 1/2-in. by 2-in. iron was forged to enclose the hinge of the magnet and a 3/4-in. bolt clamps the joint securely. The post is 1 3/16-in. round, cold-rolled steel; the rear leg and the bracket are forged, drilled and split to clamp on the post in any position. A tumbler switch is conveniently secured to the post to open and close the direct-current circuit to the magnet.

A supply of direct current is available and, with part of a heater element as an external resistance, 24 volts are impressed on the magnet winding, producing a current of 3.8 amp. The coils will carry 5 amp. without overheating. The coils could have been wound to resist full direct-current voltage, but No. 16 B. & S. gage wire was the smallest on hand.

The magneto-motive force generated is ample to overcome the reluctance of paint and irregularities on the surface. When better contact is made the magnetic density is increased and the tractive force becomes much greater.

Smooth Rock Falls, Ont., Can. W. A. PLANT.



The sketch in the upper right-hand corner shows the details of construction. The larger view shows how easily, by the use of this device, the operator was able to drill holes in a steel shell.

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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

How the Proper Design of the Equipment Affects the Economical Handling of Material

THE INFLUENCE of design upon the ease and speed as well as the economy of handling materials is well shown in the following extract from a report on "Single Bucket Blast Furnace Skip Hoist Characteristics" by A. C. Cummins and A. R. Leavitt of the Carnegie Steel Company given before the Buffalo Convention of the Association of Iron and Steel Electrical Engineers. Investigations were made on the most economical type of hoisting equipment, but it was soon seen that improvements in motoring alone would not give the full benefit expected.

It was found in making time studies that the incline design as well as the arrangements for loading and dumping the buckets could so affect the efficiency of a hoist as to nullify the results obtained from a carefully designed hoisting equipment, from the standpoint of efficiency in the use of power.

The majority of blast furnaces are rated at from 500 to 600 tons of pig iron produced per 24 hr. Nearly all of them use about the same raw material; hence, when considering the work accomplishment of blast furnace hoists, the duty cycles are in most cases not radically different. Figs. 1, 2 and 3 show incline designs of hoists on which tests were run. On casual inspection they seem closely similar, but they are quite different when performance of the hoist operation is considered.

The incline shown in Fig. 2 imposes the greatest handicap of the three upon the hoisting equipment. It will be noted that the first 30 ft. of the incline are at an angle of 45 deg., the next 130 ft. at an inclination of 68½ deg., while the final 20 ft. are at an angle of 20 deg. Each time the angle of inclination of the hoist changes there is a difference in the horizontal and vertical component of bucket velocity and in the relation of each to the other. If the changes in components of the velocity occur too rapidly, bucket oscillations are produced. In the case of

One of these inclines can be operated more economically than the others.

One of three designs of inclines for blast furnace skip hoists can be operated with motors of 100 hp. less capacity as explained in the text. This is only one example which shows that whenever a study is made of material handling methods it pays to make it thorough and include every detail of equipment design and operation.

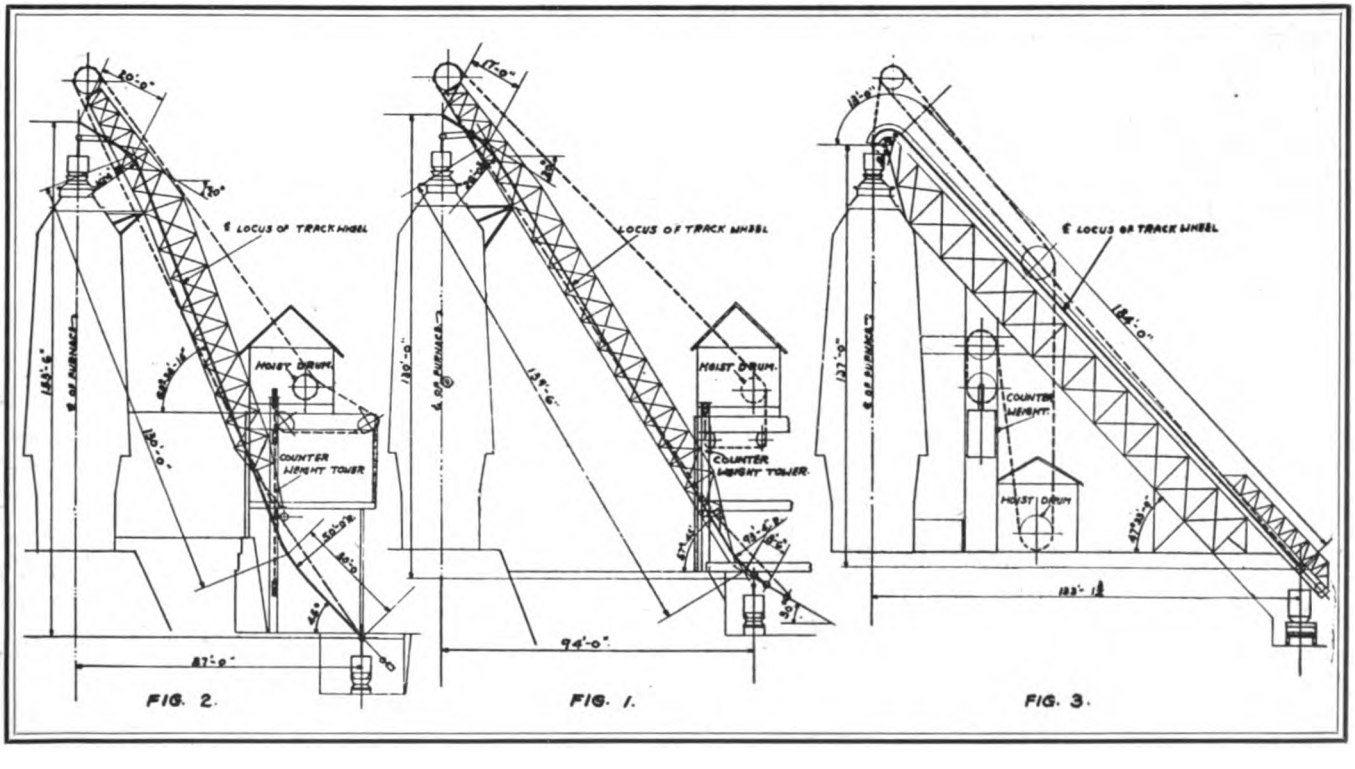


FIG. 2. FIG. 1. FIG. 3.

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the particular hoist shown in Fig. 2 this feature of the design of the incline necessitates operating the hoist at reduced speed past both points of change of incline slope. Such a condition imposes a severe handicap on the performance of the hoisting equipment for a number of reasons.

(1) So much time is consumed in passing over the slow-speed portion of the incline that the maximum speed must be made excessively high to compensate for the time so lost. The motors must, therefore, be larger, the peak power demand is higher and rheostatic losses greater.

(2) High ratio of high speed to low speed gives poor torque characteristics on some types of hoist, even though field control is used. At one plant the operators frequently must operate the magnetic controller by hand in order to pull buckets that are stuck on the incline on that account.

The incline design shown in Fig. 1 is an improvement over that shown in Fig. 2, in that the distance from the top and bottom of the incline to where the changes in angularity are made are reduced, chiefly at the bottom of the incline. The reduction amounts to 21½ ft. at the bottom of the hoist and 3 ft. at the top. This decreases the time on low speed, and hence will permit the use of lower maximum speeds and the advantages automatically gained thereby.

In Fig. 3 we have an incline design which is vastly superior in contour to those in Figs. 1 and 2. It will be noted that it is almost entirely straight, and, therefore, that the acceleration and deceleration may be started immediately, and carried through to the maximum limits as determined by safe rates and distances in which to accomplish these phases of the operating cycle.

The other feature greatly affecting the performance of the hoist is the design of the bucket filling and dumping apparatus. Time studies show that the hoists on which the bucket was detached at the bottom for filling required an average of 6, 10 and 12 sec., respectively, to change buckets at the bottom of the incline, while the two attached bucket hoists tested required a wait of 30 and 32 sec. at the bottom for filling. This difference, or an average of 20 sec. per cycle of bucket up and bucket down, must be made up by rapid hoisting. At the furnace top again there was a decided difference. The hoist shown in Fig. 3 was stopped at the top of the incline for an average of a little less than 3 sec. while dumping. As compared to this the other hoists used 12, 17, 18 and 26 sec., respectively. It would, therefore, seem that a hoist using only 3 sec. at the top for emptying the bucket represents a great time saving. The results of the time saving on the part of hoist in Fig. 3 enabled it to hoist a round of material in approximately the same time as that shown in Fig. 2 with motors of 100-hp. smaller rating, and at a maximum speed of 370 ft. per minute as compared to 508 ft. per minute.

How Two Men Supplanted a 12-Man Yard Gang for Handling Coal

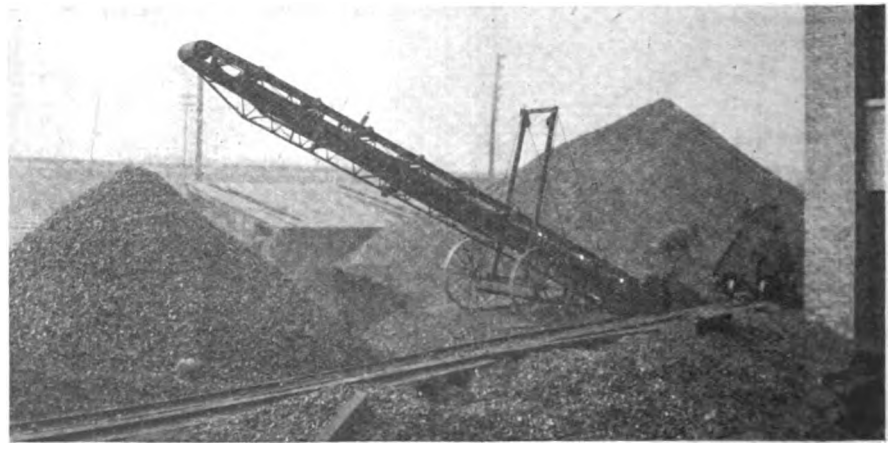
STORAGE and reclamation of coal is an important feature of yard work in many industrial plants. Because of its intermittent nature this work continually results in frequent hiring and discharge of men and causes a high labor turnover. Plants which have sufficient other yard work to keep these men busy between coal receipts are relieved of this difficulty, but nevertheless have the considerable item of expense for this work and also usually are required to maintain a gang larger than would otherwise be required.

At the Chicago plant of the Mechanical Rubber Company the storage and reclamation of coal is done by a conveyor. Here the coal as received is dumped on a trestle into a hopper from which are filled small dump cars which run on a track from the hopper into the storage yard. These dump cars are pulled up to the top of the pile by a cable and pushed to the part of the pile where it is desired to store the coal. Here they are dumped at the foot of a portable belt conveyor (Barber-Greene Company, Aurora, Ill.) which carries the coal away from the track and spreads it on the pile, as shown in the accompanying illustration. This eliminates moving the track as well as all wheeling and enables two men to do what previously had required a yard gang of a dozen or more men.

This same track also runs into the boiler room and in reclaiming coal the conveyor is turned around and used to reload the dump cars which are pushed into the boiler room and dumped. In this way the portable belt conveyor is kept busy most of the time. Meanwhile, it saves the wages of ten or more men.

Coal is spread in yard storage and reclaimed by portable conveyor.

The wages of ten or more men are saved by using this equipment instead of wheelbarrows for the storage and reclamation of coal. With such a saving as this it does not take long for the equipment to pay for itself. Ordinarily, two men now do this work but occasionally a third man is added in case a large number of cars is received at one time.



Using Second Floor for Storage With Electric Hoist

MANY CONCERNS must adapt to their own needs buildings already constructed where the handling of the material is one of the most difficult problems. For example, in one small plant it became necessary to use a second floor for the storage of heavy material. Previously this space had been used as an office and an elevator had not been installed as industrial usage had not been anticipated. Of the two possibilities—an elevator or a hoist—the latter was installed at a cost of $500 or about a third of the cost of an elevator. Also the hoist operating on a monorail was used to carry the heavy packages from the trap-door opening in the floor to storage and to the machines for processing.

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Problems of Steel Mill Operation

(*Continued from page 484.*)

F. W. Cramer spoke of the success he has had with magnetic clutches on centrifugal pumps which start and stop frequently. Formerly he operated these pumps from a control panel equipped to start and stop the motor when the water flow was started and stopped. This resulted in frequent motor burnouts. Since installing the magnetic clutches a year ago, he has had no burnouts and has not replaced the clutch lining.

In speaking on this subject, H. D. James, Westinghouse Electric & Manufacturing Company, emphasized the point that it is often better not to stop the pump or motor when the water valve is closed, but to allow the pump to churn the water. Of course, under this condition some power is consumed, although it is little compared with that used while pumping against the normal head. Moreover, the saving in wear on the motor and controller will often be much greater than the cost of the extra energy consumed.

He also mentioned the advantages of the self-starting synchronous motor for pump drive. The starter for such a motor is simple, automatic priming is easily accomplished, and bearing thermostats are readily applied. Incidentally, Mr. James mentioned that there is a popular misconception regarding the benefits of correcting power factor with small synchronous motors. He stated that the use of small synchronous motors for this purpose would prove to be expensive and quoted the case of one plant where the motors were 100-hp. in size or less. To raise the power factor to a reasonable figure in this plant would cost 20 cents per kw. if all the induction motors were replaced by synchronous motors. Only 7½ cents per kw. would be required to accomplish the same result by using induction motors and installing a large synchronous condenser to float on the line. The same results might be accomplished in a similar case by installing static condensers.

Mr. Cramer said that the advantages of electric drive for pumps are more prominent as the distance from the pumps to the source of supply becomes greater. He said that his company had some pumps in a mine which were originally fed by a long steam line. Motor drives were substituted and paid for themselves within one year by their savings.

The danger of overloading a centrifugal pump drive by decreasing the working head was mentioned by Mr. Kennedy, and two other speakers cited experiences which bore out his contention. Mr. Hipple told of a case in which a pump had been delivering 18,000,000 gal. in 24 hours. The motor ran hot and the windings frequently became brittle. It was found necessary to increase the amount of water delivered to 20,000,000 gal. per day. Since this was done the motor has been operating at a lower temperature and has never required rewinding. A. C. Cummins spoke of a similar case in which the intake to a centrifugal pump was accidentally obstructed by a block of wood. The pump had been delivering 15,000,000 gal. per day, but after the intake was partially closed by the block, the delivery increased, due to the fact that the operating head was increased and permitted the pump to operate at a higher point on its efficiency curve. As an experiment, the delivery end of the pump was also partly obstructed, still further raising the head. The delivery then increased still further to 18,000,000 gal. and the motor temperature was not raised at all.

In the discussion on the hazards of ore bridges of the skew type a practical point was mentioned by Mr. Eastwood. He told of a bridge which was driven by a spur gear that engaged a rack mounted parallel with the track. The spur gear was in turn driven by a motor through a self-locking worm gear. This arrangement assured a positive control of the bridge movement, despite slippery rails and so on. Another speaker questioned the statement of Mr. Canney in his paper, which was to the effect that rail clamps should never be applied while the bridge is in motion. He said that this statement holds for the self-locking cam type of clamp, but that at least five other types can be applied without danger. These clamps take hold of the rails gradually and when at their final position their braking force is less than the force required to overturn the bridge. He also warned that the anemometer described by Mr. Canney would give no protection against excessive wind velocity in case of an accidental opening of its electrical circuit, as it requires a closed circuit for operation.

Mr. Farrington recommended that the brakes on ore bridges be arranged so that they will be actuated by compressed air, counterweights or other means in order that they will not fail to operate in case the power is accidentally cut off.

Regarding electrification of foundry equipment C. S. Carmen said that electric power is most suitable for handling molds and drawing patterns, but for shaking sand or tamping compressed air is better.

F. A. Coleman stated that considering coke, oil, gas and electrically-heated ovens the electric oven alone is increasing in use and decreasing in operating expense. Accuracy of control is a marked advantage. Car-type ovens are preferable for large cores only, while drawer ovens excel in point of fuel cost and ease of control. Rack ovens are best from a handling standpoint. Mr. Knapp, of the General Electric Company, cited an example of one oven producing 11½ lb. of cores per kw.-hr.

Mr. Shepard, president of the Shepard Electric Crane and Hoist Company, advised the use of direct-current cranes, as opposed to alternating-current cranes.

In discussing the paper on electric furnace operation, D. M. Petty stated that the failure of power for more than 15 min. was very serious if it occurred during the finishing process.

Mr. Kennedy thought that the energy consumption mentioned in the paper seemed low, inasmuch as his experience showed that a 15-ton furnace with 24-in. electrodes requires 3,750-kva. transformers. With this furnace trouble occurred because of the burning out of back-wall refractories. Mr. Priestly stated that larger furnaces are needed in the steel industry. His experience showed that 55-ton melts could be made in 40-ton furnaces; also that the larger furnaces are easier to operate and make a more uniform and higher grade of steel.

In closing the discussion, E. T. Moore said that the ideal furnace should be operated with a low-reactance transformer and an external reactor having taps in series. During the refining period the reactance should be short-circuited. He stated that the water rate mentioned in his paper was low as experience showed that it was desirable to operate with at least a 17-deg. temperature difference between the inlet and outlet.

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Checking Up Three-Phase Diagrams

(Continued from page 498)

lead for the *A* phase can be located at the top of either group 11 or group 5. In *O* of Fig. 8 the top of group 11 is used. The bottoms of groups 11 and 2 are connected together, the tops of groups 2 and 5 and the bottoms of groups 5 and 8. The top of group 8 forms the last star connection. The tops of groups 8, 10 and 12 may be connected together to form the star point. The jumper numbers are put on at the end of the groups as already explained in reference to Fig. 6.

Line Leads May Be Brought Out at a Number of Points

The small diagram *D* in Fig. 8 represents the star connection, showing the group numbers and the order in which they are passed through. At *E* is shown the way the series-star can be changed to a series-delta connection. The star connection is opened at the end of the *A* phase and connected to the beginning of the *C* phase. Likewise the end of the *C* phase is connected to the beginning of the *B* phase, and the end of the *B* phase to the beginning of the *A* phase. If we enter the delta winding on a line lead all three phases are passed through in the direction of the arrows until the starting point is reached.

In the explanation which has just preceded, directions were given on where to place the line leads. It is not necessary, however, to place the leads always in one position. Fig. 9 shows four different methods of bringing out the line leads. The method shown at *M* is the most common, while that at *O* is used quite frequently. When selecting groups on which to attach line leads keep in mind that the arrows on alternating groups reverse, and assume that the current is flowing in on each line lead.

To check a series-delta connection start at any line lead. This will have attached to it two group connections. For illustration, suppose the *A* lead in *M* of Fig. 10 is taken. This drawing shows a series-delta, top-to-top diagram. As a starting point take one of the connections leading to the *A* lead and so mark it. For instance, in this diagram, take the *A* lead which is connected to group 11. Assume that the current is flowing in on this lead and check the direction of the current through the phase, remembering that every third group (1 and 4) should be passed through and that alternate groups are passed through in opposite directions. At the end of this phase, which is group 8, a connection is made to another line lead, *C*, which also has another group connection, 3, attached to it. Using this lead as the next starting point, check the second phase in the same manner as the first. At the end of the second phase, at group 12, another line connection, *B*, is found. This has another group, group 1, connected to it. Use this connection to group 1 as the start of the third phase. This phase should end on the same line lead on which the first phase started, at group 1. This is the marked lead.

When checking a wound stator, a piece of chalk should be used to mark each group as it is passed through. Instead of making an arrow on the end of the coils composing a group, it is much easier to draw an inclined straight line, as shown in *M* of Fig. 10. The inclination of the line toward the center of the machine indicates the direction of flow of current through the group. These lines have been drawn at groups 4-5-6-7, to illustrate their use.

How Parallel Connections Are Obtained From Series Connections

Changing series to two-parallel and four-parallel connections is shown at *P*, *Q* and *R* of Fig. 8. All the drawings in this figure are for star connections with top-to-top jumpers. Drawings *P*, *Q* and *R* show the *B* phase only. *P* is the drawing giving the series connection of the *B* phase. Drawing *Q* shows the two-parallel connection which is obtained from the series connections. The changed connections in drawing *Q* are shown by the heavy lines. The series of four coils in *P* is cut open at the middle point, the top of group 7 is connected to the *B* line and the bottom of group 10 is connected to the star point.

At *S* is shown the entire two-parallel star connection with all three phases drawn in. Note that the two star connections are not joined together. The electrical performance is not affected by failure to join the two stars and on large machines where the wire is of considerable size, two splices and some cable are saved by omitting the connection between the two stars when a change is made from series to two-parallel.

A four-parallel connection is shown at *R*. Each connection consists of only one group in this case. This is because there are only twelve groups while there are four parallel circuits for each of the three phases. At *T* is shown the complete four-parallel star winding with all three phases drawn in.

The method of drawing and checking parallel-delta connections is shown in Fig. 10 at *N* and *O*. These windings are for top-to-top connections. A two-parallel delta connection will have four taps to each line lead. Then to check the winding take any one line lead as *A* in drawing *N* of Fig. 10. Take any one of the four taps from this line lead, such as the tap connected to group 11. Assume that the current is flowing inward on this tap. Then trace through the groups of this phase, remembering that every third group (1 and 4) is in this phase and that alternate groups should be passed through in opposite directions. Mark all the leads and also the groups as well as the direction in which they are passed through. After the groups in this phase, groups 11 and 2, are passed through, the *C* phase begins. Select a tap on this *C* phase, as that going to group 3. Check through groups 3 and 6 to the *B* line lead. Check this phase through groups 7 and 10. After passing through these three half-phases, we come to the line lead started on, which is *A* in group 10. We shall have marked six taps which were passed. Then starting again on the first line lead, select another tap, this time on group 5, in the *A* phase. Check this circuit through. Then follow each remaining tap at the end of each remaining half-phase until the starting point is reached.

At *O* is a four-parallel, delta connection. Each group is the beginning and the ending of a phase. To check such a winding pass first through any *A* group, then a *C* group, then next a *B* group. This completes the first circuit. Then select another tap leading from a line and pass again through the *A*, *C* and *B* groups. When this is done four times all of the windings will have been included.

The method of constructing a top-to-bottom diagram is shown in Fig. 11. In this type of diagram all

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groups in one phase under poles of the same polarity are connected in series. Then a reversing jumper connects this series with the groups under poles of the opposite polarity and these also are all connected in series. When a three-phase motor has top-to-bottom jumpers, groups 1 and 7 are connected together. In *M* of Fig. 11, the top of group 1 is used for a line lead and the bottom connected to the top of group 7. This forms the first series of coils in this phase, as half of the groups in this phase have been covered. Then a short jumper connects the bottom of group 7 to the bottom of group 10. The top of group 10 is then connected to the bottom of group 4, and the top of group 4 forms the star connection. At *N* of Fig. 11 is shown the two-parallel, top-to-bottom connection. Note that the short jumper has been cut open, one end going to a line lead and the other to the star connection.

Other examples of the top-to-bottom connection are included in Fig. 12. This shows a six-pole, series-star diagram, connected top-to-bottom. At *M* is the series connection. At *N* is the two-parallel connection in which the three north-pole groups are in one circuit and the three south-pole groups in the other circuit. In *O* a three-parallel (three-circuit) top-to-bottom connection is shown. In this diagram one of the circuits has a top-to-top connection, where groups 13 and 16 are connected together. The reason is that these two were originally connected together by the short jumper.

Relation of Lighting to Production

(*Continued from page 488.*)

making a total cost of about 32 cents per hour. With the old 5 foot-candle lighting system, about half of which was daylight, the cost for current and lamp renewals was $0.04 per hour. The inspectors receive an average wage rate of approximately $0.30 per hour or for 44 people a total of $13.20 per hour. A 12.5 per cent increase in production means, therefore, a saving of $1.47 per hour in labor, which is five times the added cost of the lighting.

This is arrived at as follows: A 12.5 per cent increase in production means that less men are needed to obtain 100 per cent production; the number needed would not be 87.5 per cent of the original number but 88.9 per cent. This is easily shown from the equation where X + .125X = 100 per cent; then X=88.9 per cent. Accordingly if only 88.9 per cent of the men are needed with better lighting whereas 100 per cent formerly were required there would be a wage saving of $13.20 minus $13.20 times 88.9 per cent or $1.47 per hour in labor which is five times the added cost of the lighting. To put the matter in another way the new lighting increased production 12.5 per cent at a total cost of less than 2.5 per cent ($0.28÷$13.20) of the payroll of the department where forty-four people were employed.

The authors desire to express their appreciation of the valuable services rendered by Mr. C. M. Snyder in the conduct of the tests which have been described.

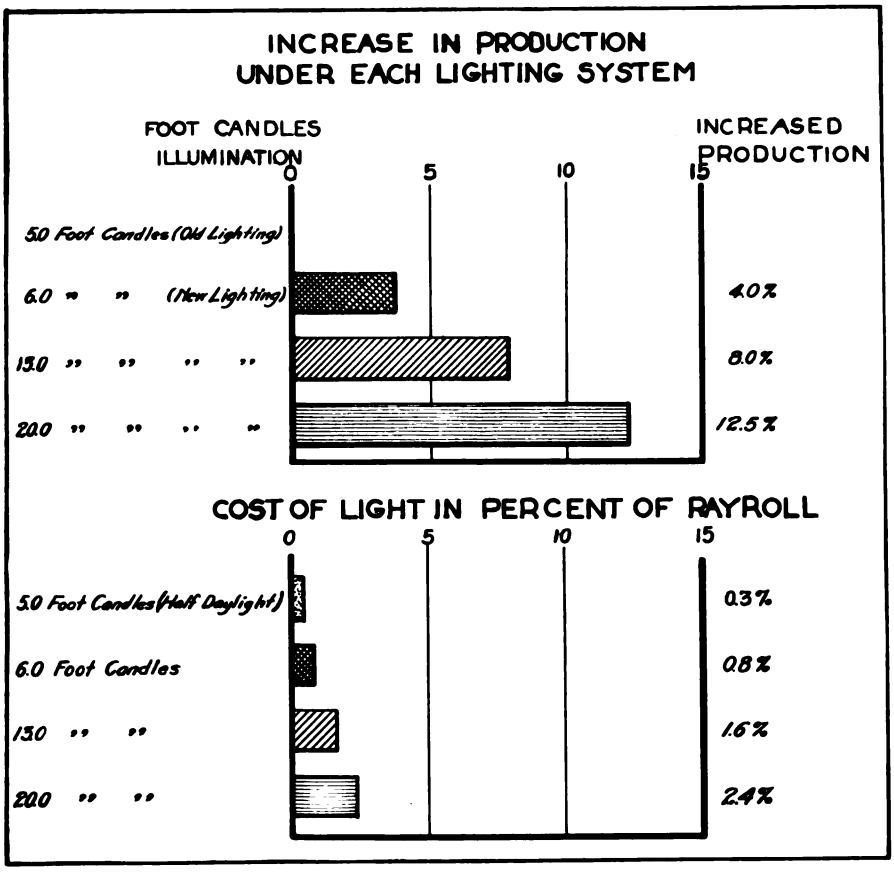


Fig. 11—This diagram shows the increase in production under different lighting intensities and the cost of light in per cent of the payroll found by tests conducted in plant of The Timken Roller Bearing Company, Columbus, Ohio.

Rigid and Compression Couplings

(*Continued from page 501.*)

A coupling of the first type is shown at *E*. The sleeve is usually either split or slotted so that as the flanges are tightened up the compression grips the shaft firmly due to a proportionate contraction of the bore. In installing these couplings, care should be taken to see that oil does not get onto the shaft underneath the sleeve and that the bolts are tightened up evenly. Reducing couplings are made either by using a sleeve bored out for the two diameters or by inserting an extra slotted sleeve or bushing equal to the difference in diameter inside the larger sleeve. However, reducing couplings of this type should not be used to connect shafts of more than ½ in. difference in diameter.

Sometimes instead of using the bolted flanges, threaded ring nuts are used. A coupling of this type is shown at *H* and *I*. This type generally uses a key in addition to the gripping strength of the coupling. Here the sleeve is split in half longitudinally and held in place by driving a cone tapered ring on each end, after which the ring nuts are tightened up. As the surface of this coupling is smooth and polished, it is frequently used in textile mills as there are no recesses or projections wherein dirt, dust or lint may collect.

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Another compression coupling of this type (*F*) consists of two tapering half-sleeves and two forged steel rings. The split sleeve is turned tapering on the outside and the rings are bored to match. The sleeve is placed over the end of the shaft and the rings driven on as far as they will go. This grips the shaft securely and is easily removed. It is often used on outdoor work as it is easier to drive the rings off than to remove rusted bolts. Straight keys are used with this.

A coupling of the third type is shown as *J* and *K*. In this type of coupling the two cones are drawn together by bolts. As the cones are slotted on one side, the outer sleeve forces them tightly against the shaft.

The fourth type of coupling is very much like the first type of coupling with flanges except that the sleeve is slotted in a spiral instead of longitudinally. The spiral gives a very strong gripping effect.

None of these couplings is adapted to direct-connecting shafts of two high-speed machines because of the difficulty of keeping perfect alignment of the shafts. For this purpose some form of flexible coupling should be used. The various types adaptable will be discussed in another article.

EDITOR'S NOTE: Special acknowledgment is made to John J. Serrell, Smith & Serrell, Newark, N. J., and to the following companies for their kind assistance in furnishing information, counsel and illustrations for this and the other articles which are to follow in this series: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; The Bartlett-Hayward Co., Baltimore, Md.; Charles Bond Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; Brown Engineering Co., Reading, Pa.; The Carlyle Johnson Machine Co., Manchester, Conn.; Chicago Pulley & Shafting Co., Chicago, Ill.; Conway & Co., Cincinnati, Ohio; The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; I. H. Dexter Co., Goshen, N. Y.; Dodge Manufacturing Co., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; General Electric Co., Schenectady, N. Y.; The Hanson Clutch & Machinery Co., Tiffin, Ohio; The Hill Clutch Co., Cleveland, Ohio; The Hilliard Clutch & Machinery Co., Elmira, N. Y.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Medart Co., St. Louis, Mo.; Mesta Machine Co., West Homestead, Pa.; R. D. Nuttall Co., Pittsburgh, Pa.; The Pusey & Jones Co., Wilmington, Del.; Reeves Pulley Co., Columbus, Ind.; R. H. & F. M. Roots Co., Connersville, Ind.; A. L. Schultz & Son, Chicago, Ill.; Smith & Serrell, Newark, N. J.; Thomas Flexible Coupling Co., Warren, Pa.; Weller Mfg. Co., Chicago, Ill.; Western Engineering & Mfg. Co., Chicago, Ill.; The Williams Foundry & Machine Co., Akron, Ohio; T. B. Wood's Sons Co., Chambersburg, Pa.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

The Electric Controller and Manufacturing Company, Cleveland, Ohio—Bulletin 1046 describes the Type ZK Manual-Automatic Compensators for alternating-current, squirrel-cage motors. Fifteen advantages claimed for this equipment are included.

The Falls Clutch and Machinery Company, Cuyahoga Falls, Ohio—Catalog 18 entitled "Power Transmission Machinery" devotes over 300 pages to engineering information, data, price lists and descriptions of the various lines of shafting, couplings, collars, friction clutches, pulleys, sheaves, bearings and belt tighteners manufactured by this company for transmission purposes.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A miniature publication entitled "Electric Heat" and devoted to industrial electric heating problems will be published frequently. In addition to articles on the operation and advantages of electric ovens, a method is given for calculating the power requirements for heating electric ovens. Mailed upon request.

Electric Arc Cutting and Welding Company, 152 Jelliff Avenue, Newark, N. J.—A 52-page booklet describes the "Alternarc" portable welding and cutting apparatus, the important feature of which is that by the use of a special transformer alternating current can be used. These transformers may be carried by two men. A number of pages is devoted to illustrations of various types of welds and descriptions of methods of using the welding and rivet-cutting apparatus.

The Standard Electric Tool Company, Cincinnati, Ohio—Recent literature describes the new improved type of electric drill bench stand which it is claimed more than doubles the value and usefulness of an electric portable drill.

The American Foundry Equipment Company, 366 Madison Avenue, New York City—A folder describes the American Type K foundry sand cutting machine and gives a number of illustrations showing what it can do in use.

General Electric Company, Schenectady, N. Y.—A booklet entitled "Thirty-Year Review of the General Electric Company" devotes 34 pages in tracing the development of applications of electricity through the early pioneering work and the astonishing growth of the business, the rapid increase in the size of generating units, and the ever-widening application of electric power.

Condit Electrical Manufacturing Company, South Boston, Mass.—Bulletin No. 445-2 describes the Type D-17A and D-17B oil switches and circuit breakers for manual and electrical control in either automatic or non-automatic types. The capacities range from 7,500 volts to 25,000 volts.

Gisholt Machine Company, Madison, Wis.—A booklet entitled "The Missing Link" describes the use of the "Periodograph" in keeping control of the time spent in production and in idleness in industrial plants.

The Okonite Company, Passaic, N. J.—A booklet entitled "Splices and Tape," discusses the importance of a perfect splice, the important properties of tape, how to recognize these properties, and how to make a perfect splice. A description of the various tapes made by the Okonite Company, and their uses, is included.

The Unique Plumbers' Furnace Company, Tipton, Ind.—Catalog 5 entitled "Unique Soldering Supplies" explains the construction and operation of the "Unique" torches and firepots, burning gasoline and kerosene. Kerosene-burning equipment is provided with a special generator having a large generating surface which, it is claimed, increases the heat obtained and eliminates effect of wind. Economy and reduction of fire hazard are some of the advantages claimed.

Motorbloc Corporation, Summerdale, Philadelphia, Pa.—A 4-page bulletin describes the "Motorbloc," which is a motor-driven chain hoist, in its various industrial applications, in addition to giving details of construction and specifications of the various sizes.

Reliance Electric and Engineering Company, Cleveland, Ohio—Bulletin 5018 describes the new Type AA Reliance induction motors for two- and three-phase alternating current circuits. Many illustrations of the design and construction of the various features of this motor are included.

Appleton Electric Company, 1701-1713 Wellington Avenue, Chicago, Ill.—Catalog 9 describes the line of "Unilets" and other conduit fittings manufactured by this company. A special feature of this catalog, in addition to the general index, is a "Pictorial Index" which illustrates the different types of Unilets and other fittings and refers to the page on which each may be found.

Edison Lamp Works of General Electric Company, Harrison, N. J.—Bulletin LD-143 entitled "Lighting of the Food Industries" devotes 32 pages to a discussion of the proper amount of lighting recommended for grain elevators, flour mills, bakeries, meat packing, ice cream and candy manufacturers, fruit packing and other food-product industries.

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INDUSTRIAL ENGINEER

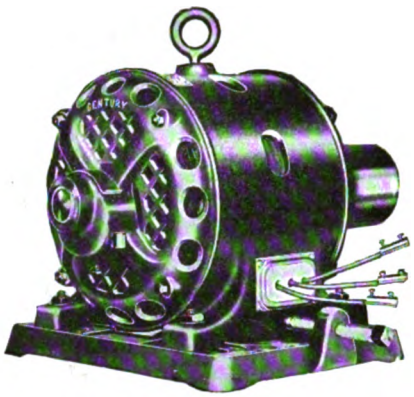
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

November, 1923

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Type "SC" motors are ruggedly constructed, embodying many desirable characteristics, two of which are:

Genuine phosphor bronze bearings, the best obtainable, with machine cut figure 8 oil grooves allowing a thorough distribution of oil.

The squirrel cage construction consists of high conductivity copper bars brazed into formed U shape cross section rolled copper end rings, with a material that will not melt under the most severe operating conditions.



They Keep-a-Running

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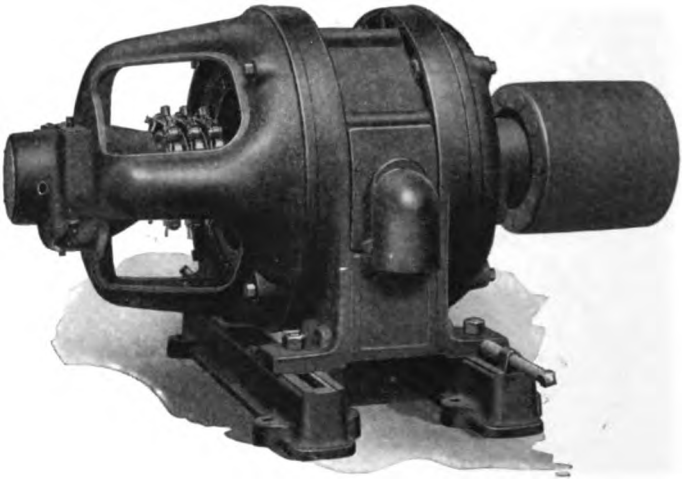
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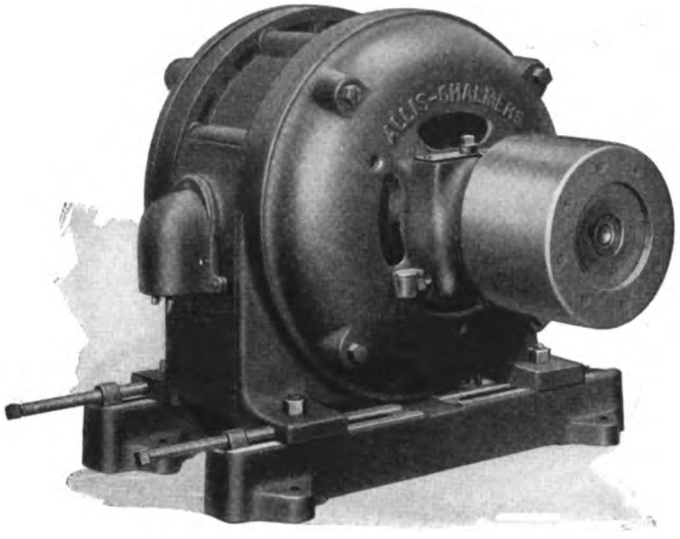
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Type "ARY" Slip Ring Motor



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Constant and Variable Speed

60 and 25 Cycle

Type "AR" and "ARY" Motors

Designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.

Method of ventilation is very effective resulting in even cooling and avoiding of "hot spots."

Bearings are of liberal design with spacious oil-wells.

Insulation is of highest grade, stator being treated with baked-on insulating varnish making the whole structure dust and moisture proof.

Motors are for floor or ceiling mounting being provided with very stiff and substantial rails.

Conduit terminal boxes are regular equipment.

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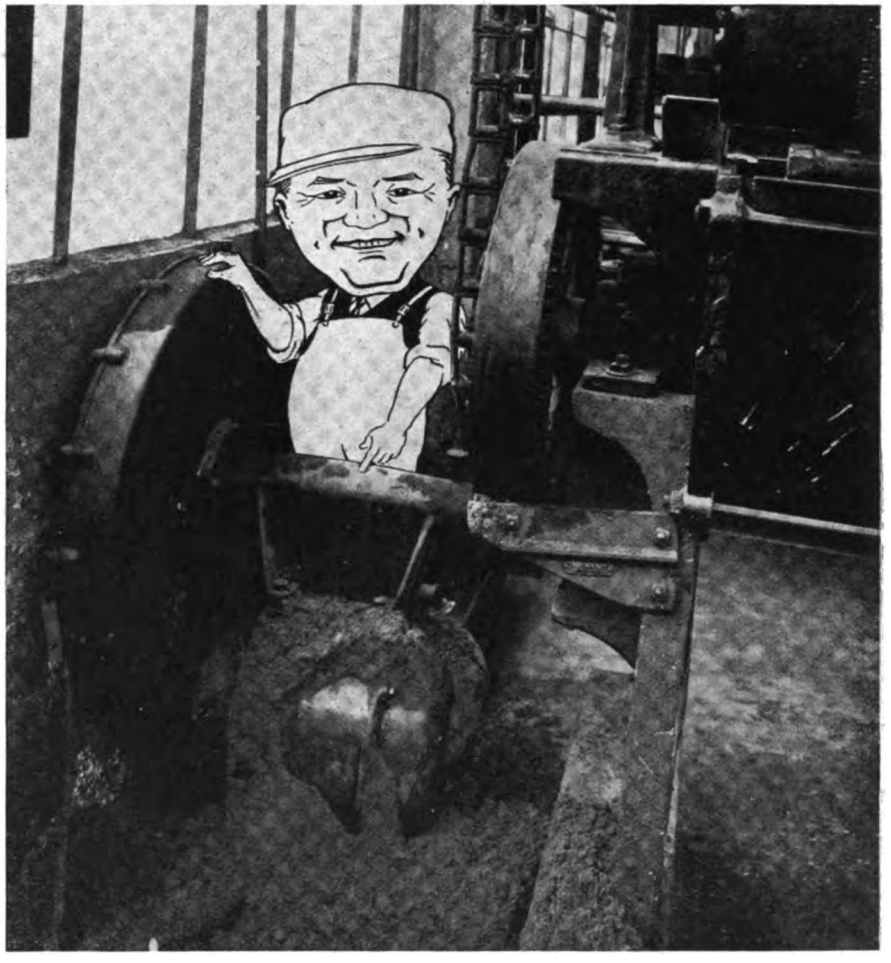
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 Chicago, November, 1923 *Number 11*

Buying Motors to Use— Not to Repair

Is a real job under some industrial installation and operating conditions —How do you do it?



HERE is a photograph that I have received from Mr. Mark Hoeper of the American Electric Motors Inc., Milwaukee, Wis., which shows surroundings where the Imps of Satan like to dance about when successful in creating for the repair man bearing and winding troubles in open types of motors. Such troubles are here avoided by the use of a self-ventilated, totally-enclosed, ball-bearing motor for which a non-maintenance service record is claimed. In this connection Mr. Hoeper says:

This dirty picture shows the conditions under which this 5-hp., 1,200 r.p.m., ball-bearing motor must operate in driving a core sand mixer.

More or less sand is spilled out of the mixer cylinder and gradually considerable of it accumulates on the motor. The air inlet manifold for the ventilation does not appear on the photograph as it is mounted on the back side of the motor for convenience in piping clean air to the motor through the outside of the building. The back gears, you will notice, are totally enclosed, so that they run in a bath of oil or grease, and so that no dirt can get inside of the gear case. The back gear frame can be mounted on top of the motor or on either side. The back gears can be mounted at either end of the motor and the air inlet manifold can be mounted in any of these three positions not occupied by the back gear shaft assembly.

Dust, grit, fumes, oil, and water, drive more motors into the repair shop than long years of hard service under favorable operating conditions. Every man who has to fight against these trouble-makers listens with ears and eyes when new or better remedies are proposed for they save his time for other duties and help to reduce the installation and maintenance costs that are charged to his department.

I am looking all of the time for the men who have worked out installation, inspection or other methods to enable motors to live their lifetime with the lowest repair and maintenance cost.

If any of you who read this have a pet scheme or an installation that has done the trick and kept your motors on the job and out of the repair shop, I shall certainly appreciate the details so that we can talk the matter over together on this page and after a while get somewhere on this question of buying motors to use and not to repair.

Practical Pete

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A Glimpse into the Works of the

American Sugar Refining Company

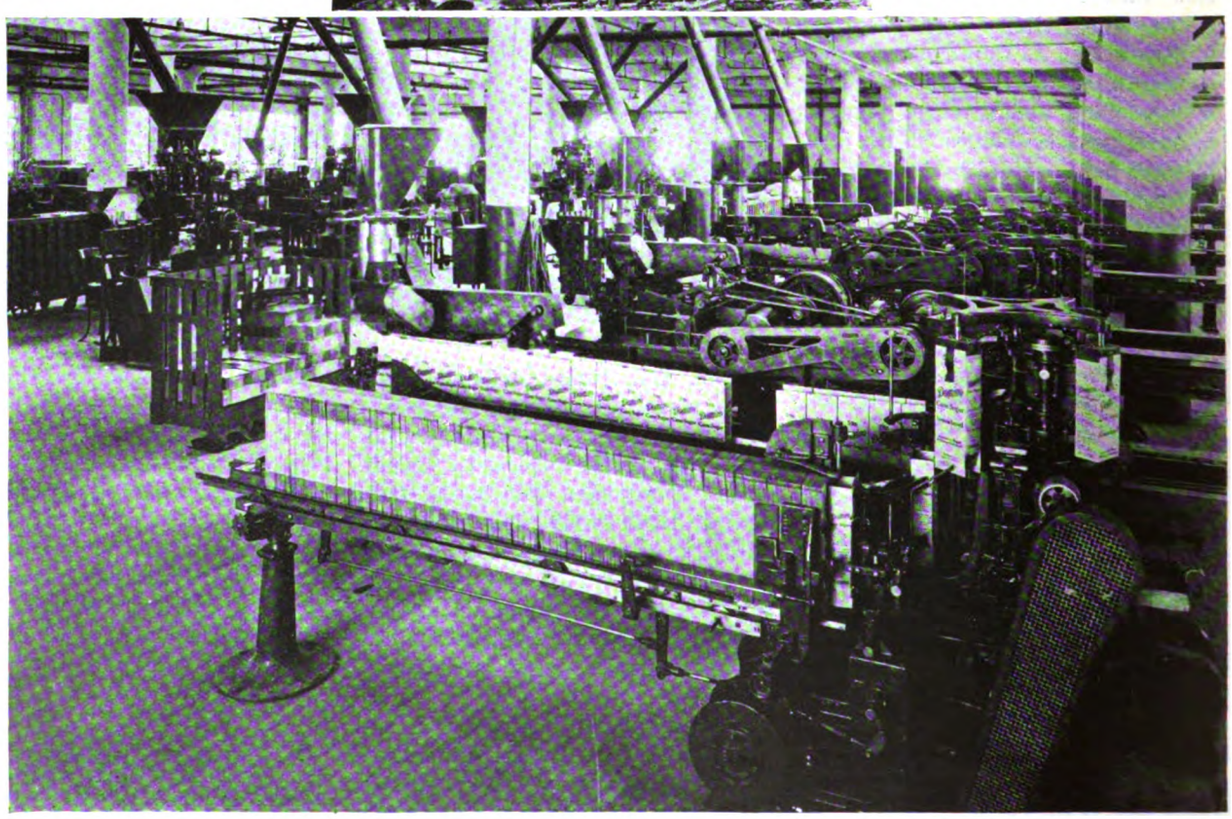
Where raw sugar is refined by twenty to thirty processes into forty-four grades and put into ninety-six packagings for use. The eleventh of a series devoted to the growth and extent of our basic American industries.



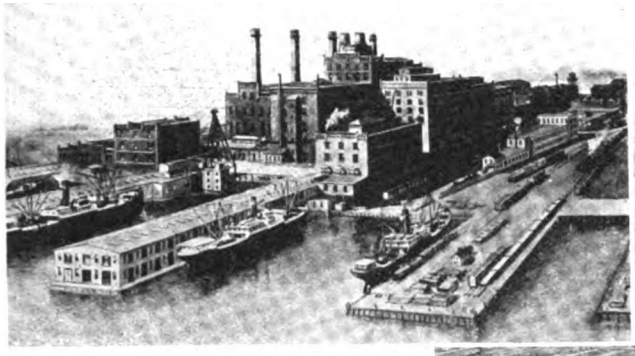
Two views of the Baltimore, Md., plant and an automatic packaging machine filling 5-lb. cartons with "Domino" granulated sugar. The folded cartons are fed into a mechanism which opens them, closes and seals the bottom. The cartons then pass on to the filling machine where they are filled weighed, closed, and sealed automatically. In process the sugar is not touched by hand.

A TRAIN of box cars reaching from Boston to Denver would be required to haul all the 5,000,000 long tons of refined sugar consumed annually in the United States, which is about a fourth of the sugar produced in the world. The section of this train between New York and Cleveland would hold about the amount produced by the American Sugar Refining Company, which is around 1,500,000 long tons. Sugar has been known since the beginning of the Christian Era. At first it was costly and was used only in medicine. During the past hundred years it has come into general use because mechanical improvements in the refinery have made the production of sugar possible at low cost and within





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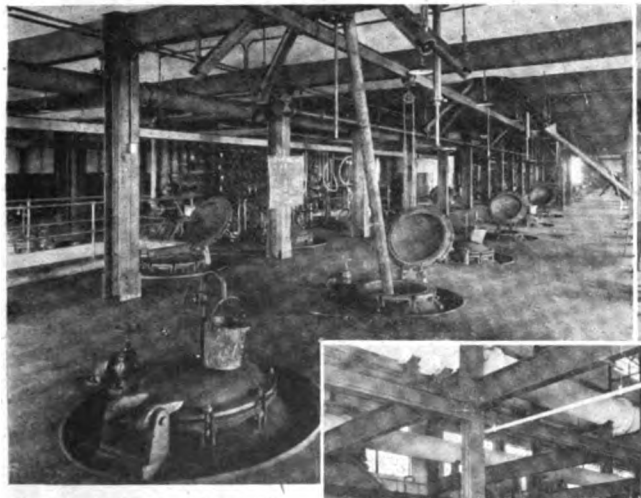
Three other plants of the American Sugar Refining Company.

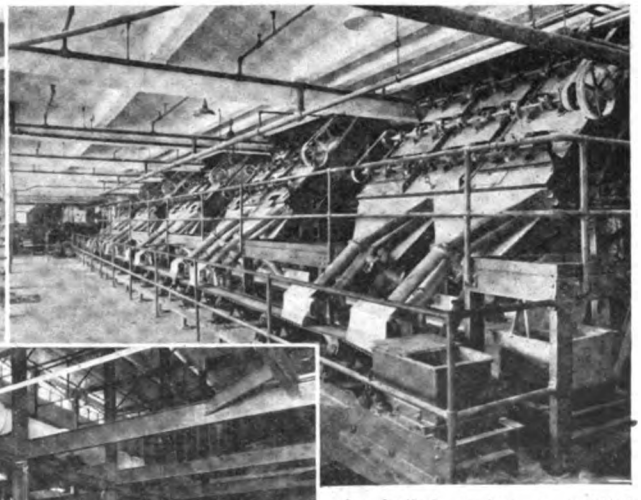
The plant above at the left is the Philadelphia refinery. The one above at the right is the Brooklyn refinery, which is about 60 years old and until 1890 was the largest refinery in the country. It was originally one of the Havemeyer factories which was later incorporated into the American Sugar Refining Co. The airplane view is of the Chalmette refinery near New Orleans. All have adequate waterfront.

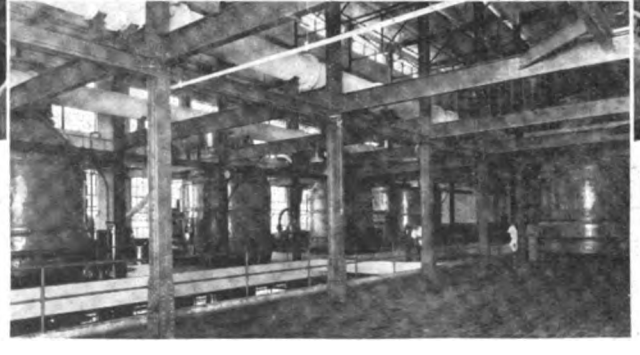
the purse of all. However, a hundred years ago granulated sugar was still unknown.

The art of refining consists in converting raw sugar into refined grades with a minimum loss of sucrose content. Today, a loss of 6 to 7 lb. in a hundred, in refining raw sugar of average test, is all that is expected. In 1816 a refiner could obtain from 100 lb. of raw sugar only about 50 lb. of refined sugar, 25 lb. of molasses and 25 lb. of so-called bastard sugar. The present method of refining involves between twenty and thirty steps, or processes, depending upon the grade or form of the refined product. The American Sugar Refining Company manufactures forty-four kinds or grades of refined sugar put up in ninety-six ways.

In the course of a century, the invention of the centrifugal machine, the vacuum pan, the bone-black filter and the polariscope has revolutionized the refining methods. The fundamentals, to be sure, remain the same as in Colonial days. It was then necessary to melt, clarify, filter, and crystallize by boiling the raw product. Today the same steps must be followed, but the methods employed in the various processes have all been changed radically. Formerly, raw sugar was melted in a large open kettle or copper boiler; the liquor filtered by straining through blankets, and then clarified by the use of bullock's blood, albumen and clay. The purified sugar was then run into molds and placed in ovens which were heated to the proper temperature. This formed the old loaf sugar. The use of the bone-black filter has done away with the old clarifying agents, ox-blood, clay and albumen. Bone-black quickly and thoroughly cleans raw sugar. Employing it together with bag filters and filter







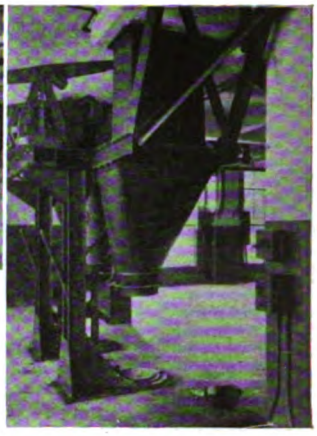
Three steps in the refining of sugar.

The dissolved raw sugar syrup is poured into the filters above where the syrup passes through boneblack, charcoal made from animal bone, to remove the impurities. It then goes into the vacuum pans above where it is boiled under a partial vacuum at a temperature low enough to prevent the sugar from carmelizing. The above illustration shows a battery of screens which receive the finished sugar from the centrifugal machines. It is discharged on a belt conveyor which carries it to chutes emptying into storage.

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Three steps in packing refined sugar.
Altogether this company produces nearly 100 varieties or grades and packages of sugar. Above at the left the girl is packing. "Domino" sugar, in small sacks. The other two illustrations show equipment for filling and carrying barreled sugar.

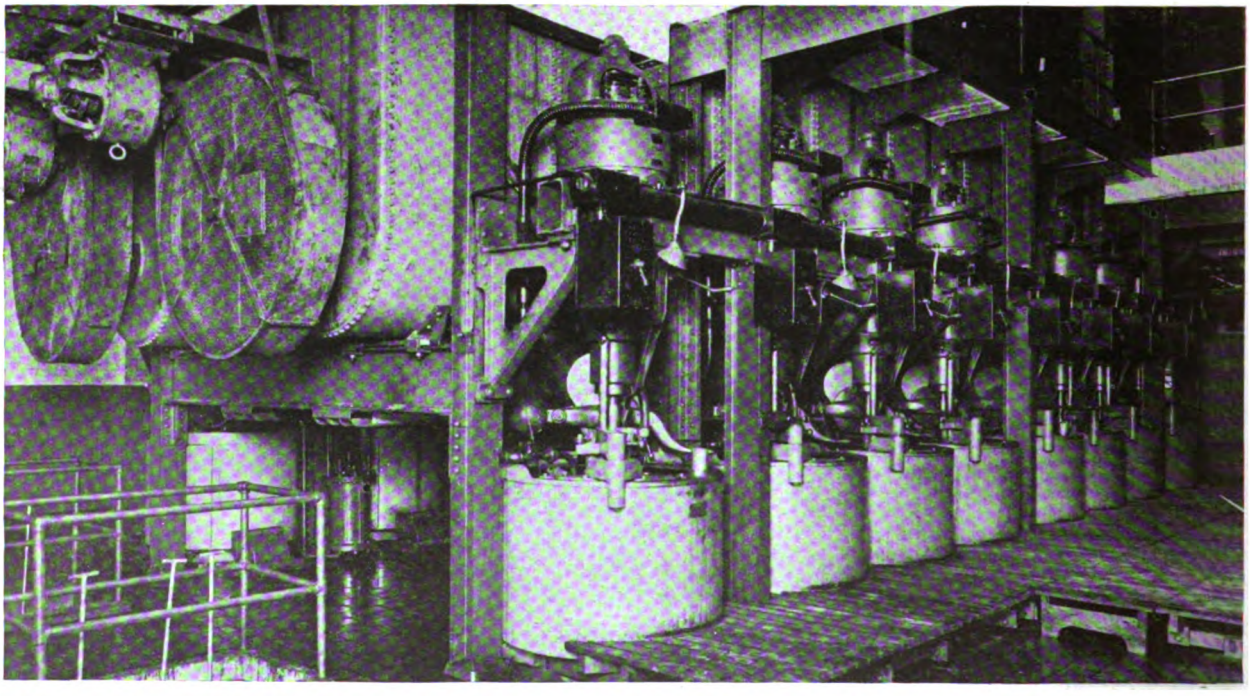
presses which take the place of the old-fashioned blankets, the modern refiner is able to produce sugar free from any impurities.

The polariscope now makes it possible to determine exactly the sucrose content, that is, the amount of pure sugar in any raw sugar. By its use the buyer of raw sugar is able to ascertain to a fine degree the value.

Granulated sugar has been made possible by the invention of the centrifugal machine and the modern granulator. Sugar liquor, after boiling, is put into the centrifugal machine, a large perforated drum which revolves about 1,100 r.p.m., throws the molasses off and leaves the white sugar granules in the basket. The granulator dries the sugar and divides it by screens into three grades. After the sugar has been manufactured, it is conveyed and packed entirely by clean machinery which weighs it, places it in cartons, cotton bags or barrels and seals it.

What might be called the start of the American Sugar Refining Company was a refinery erected by the Havemeyers in the early part of the nineteenth century, in a little building, 25 ft. by 40 ft. in size, with only four or five employes. The sugar business which started in this little refinery was handed down from generation to generation, expanding until in 1890 it was the largest refinery in the world. About that time this refinery and several others were combined to form the American Sugar Refining Company. Today the largest refinery of this company can refine in two days approximately the total amount of sugar refined in New York City in 1816. The company has refineries in Baltimore, Brooklyn, Boston, Philadelphia and Chalmette, near New Orleans. It also owns two sources of raw sugar supply in Cuba. These require 12,000 men for 150 days to cut and haul the cane, and 1,300 more for the *(Continued on page 564)*

A battery of centrifugal machines with direct-connected motor drives. After the sugar has crystallized in the syrup from the vacuum pans the liquor is poured into these centrifugal machines. These consist of perforated drums which revolve at high speed and throw the syrup out while retaining the sugar. The sugar then goes on through the screens and finally to the packing rooms.



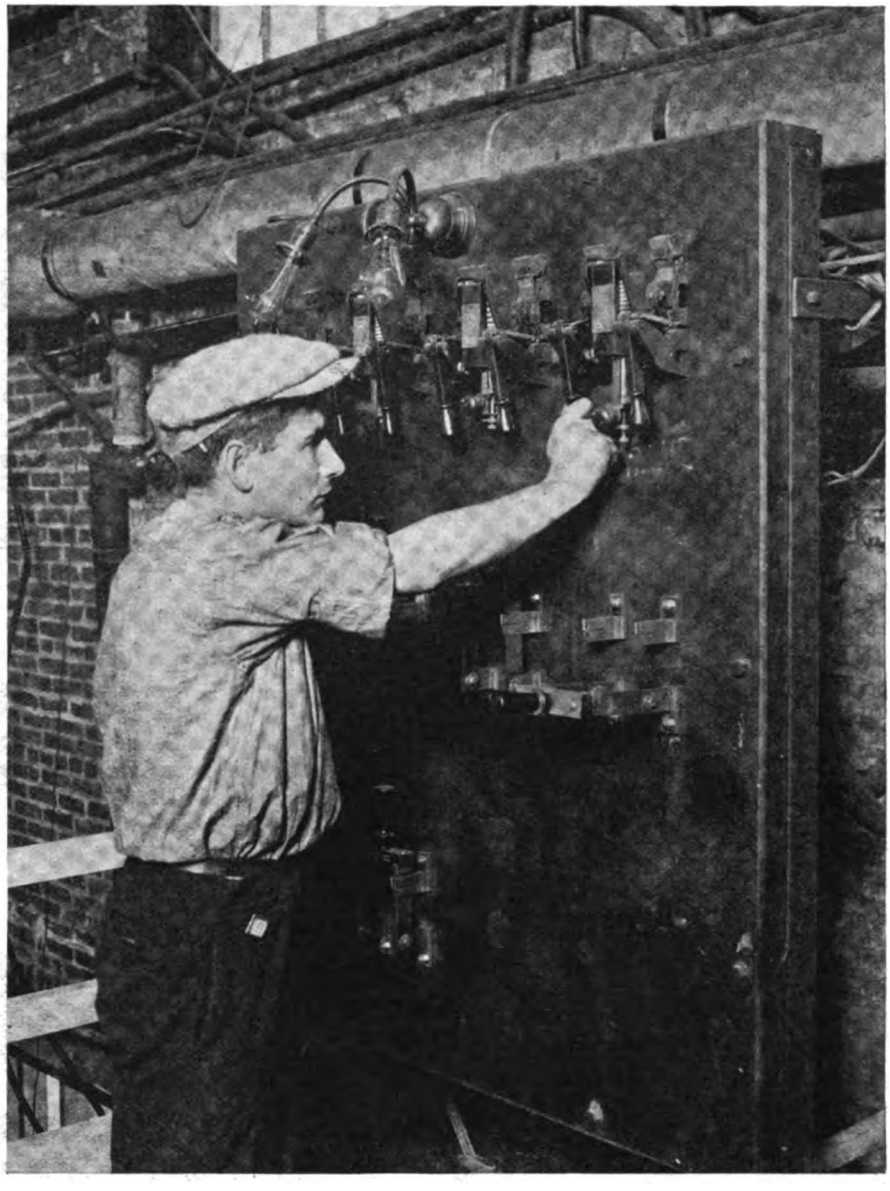
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CIRCUIT BREAKERS when correctly installed will often save more than they cost. They will protect service lines, motors, driven machines, and prevent waste of the product being made. In addition they will reduce service interruptions and the losses accompanying them, which is often a large item in production costs. In this article information is given that will help to determine the type of circuit breaker that is best suited to service conditions and protection for direct-current motors. A later article will cover protection for alternating-current motors and power and lighting feeders.

Some Practical Pointers on

Circuit Breakers for D. C. Motors

Their Operation Under Differing Load Conditions and Hints on Care



The operator is shown here putting in the breakers that protect a crane.

By JAMES H. WYATT

Assistant Engineer, Cutter Electrical & Mfg. Company, Philadelphia, Pa.

AN OVERLOAD circuit breaker should protect the motor and motor-driven machine from being unduly loaded through any cause whatever. Overloads may be occasioned by too rapid starting of the motor, by working the motor-driven machine beyond its capacity, by faulty adjustments in the driven machine, by the presence of foreign bodies in its working parts, and by a variety of similar causes.

In the selection of overload circuit breakers for direct-current motor protection, due attention should be paid to the amount of current required at starting. With hand-starting rheostats of the usual types the starting currents of direct-current motors of the sizes in ordinary commercial use run in the neighborhood of 150 per cent of full-load current, and circuit breakers should be chosen which have a sufficiently high adjustment to meet this requirement satisfactorily. Table I indicates the sizes of circuit breakers best adapted for the protection of various sizes of motors from ½ hp. to 100 hp. at 125, 250 or 500 volts, direct current. The figures given in the left-hand column indicate the horse-power of the motors at full load; the remaining columns show the ampere ratings of the circuit breakers required for each of the voltages given.

Close Protection With Heavy Starting Currents

Where the operating point of the overload circuit breaker is set only slightly above the point corresponding to the load current, the circuit breaker, when connected in the motor circuit, will instantly open in the event of any serious irregularity of operation such, for instance, as the catching of a tool or the jamming of material. The degree of protection which may be secured against such contingencies is limited ordinarily by the amount of current required for starting the motor, because, unless some special construction or method of operation is employed, the setting of the circuit breaker must be slightly in excess of that corresponding with the starting current. Under ordinary conditions the circuit breaker, when set in this manner, will still be sufficiently sensitive to afford the desired measure of protection. But where the material being worked is of great value and of a readily destructible nature, or where the machinery involved is fragile, complicated and easily thrown out of adjustment, sensitiveness to even slight increases in the load above the normal is a most desirable characteristic of the circuit breaker.

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This exacting condition may be met by the use of a specially constructed circuit breaker provided with two independently adjustable overload features, one operative throughout the starting period, and the other only when the starting resistance is cut out. By this means the sensitiveness of the circuit breaker during running conditions, being entirely independent of the current required for starting, may be increased to any desired point.

Obtaining Protection Against Sustained Overloads

In contrast with the foregoing there are other and much more usual conditions in which it is not desirable to have the circuit breaker operate in the event of briefly sustained overloads of inconsiderable magnitude, but to limit its action to that occasioned by sustained overloads or those of excessive magnitude. Such conditions are met, for instance, in the operation of motor-driven punches, rolls or shears, in which the load comes upon the motor intermittently, thereby causing sudden and considerable, although briefly sustained, increases in the current flow. For such service the overload feature should have an inverse-time lag; that is, it should be sensitive to small overloads only when continued unduly, but should respond more quickly to the heavier overloads, the time lag becoming less as the overload increases, and altogether disappearing in the case of excessive overload. The ordinary form of overload circuit breaker does not discriminate between momentary and sustained overloads, but in any case operates the instant the current flowing exceeds that for which the instrument is adjusted. If, to meet these conditions, the tripping point of this form of circuit breaker be set so high as to be unaffected by momentarily excessive currents it will be likewise insensitive to sustained overloads of the same magnitude, and to this extent will be ineffective as a means of protection. If, on the other hand, the tripping point be set so as to give protection against current values which, if sustained, would cause damage, then momentary fluctuations of the current to the same magnitude will occasion unnecessary opening of the circuit breaker. These small momentary increases of current would not, of course, harm the motor.

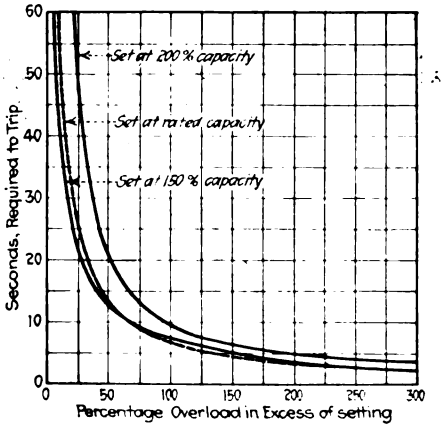


Fig. 2—A good circuit breaker acts similarly with any setting.

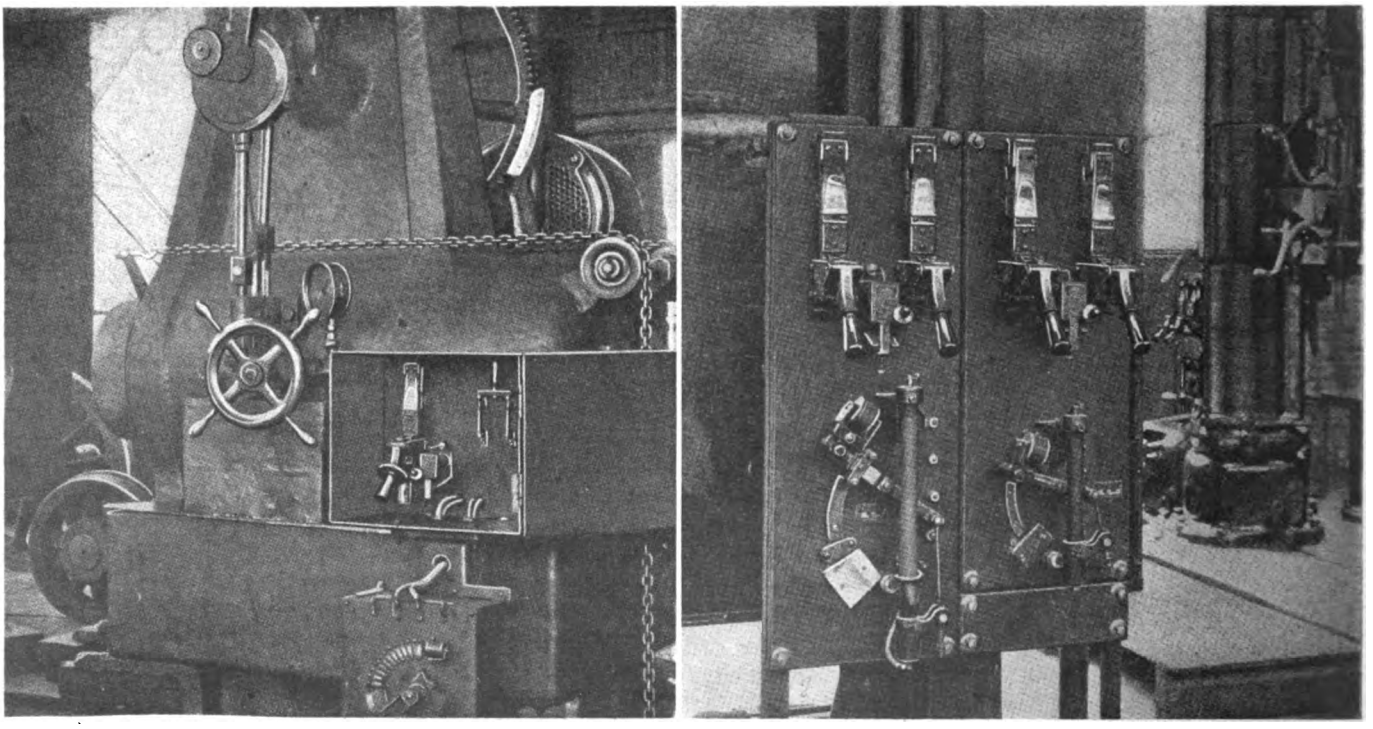
These curves are for a 150-amp. breaker with a properly designed inverse-time feature. The dotted line shows the time required to trip the breaker at different loads when set to trip at normal rating. When set at a higher value its action as seen from the curves is nearly the same. For instance when set for rated current, if a load 50 per cent above the setting comes on, the breaker will trip in about 13 seconds. Again if set for 150 per cent of normal current, it will take approximately 12½ seconds to trip at a current 50 per cent above this.

Characteristic curves of the operation of a circuit breaker with the time-lag feature are shown in Fig. 2. The breaker is rated for 150 amp. It will be seen that if a load of 300 amp. comes on the motor (100 per cent overload) the breaker will trip in about seven seconds. If a load of 600 amp. (300 per cent overload) comes on, the breaker will trip in two seconds.

There is another desirable feature of a circuit breaker which these curves bring out. This feature is constancy of action under various settings. This means that the 150-amp. breaker may, perhaps, be set to trip at 200 amp. on short circuit. This is 50 amp. above its nameplate

Fig. 1—Circuit breakers on motor panels.

At the left is an application of breakers with motor starters. These breakers replace both hand switches and fuses. In case of an overload on the circuit the first breaker opens as the second is being closed. These panels are in the plant of the Kempsmith Machine Tool Company, Milwaukee, Wis. At the right is a board showing breakers which protect and control power feeders and individual motors in a plant of the Diehl Manufacturing Company.



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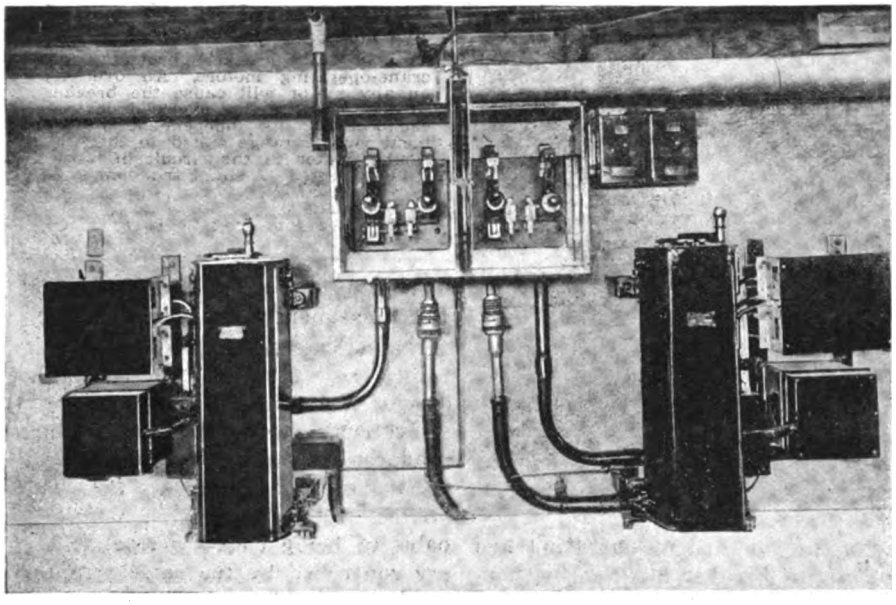


Fig. 3—Circuit breakers mounted at the drum controllers of two 75-hp. motors driving molasses pumps.

tripping current. Now if it is a good breaker it will act at this higher setting the same as it did at its normal setting. In other words at 100 per cent overload above 200 amp. it will trip in about 7 seconds, just as it tripped in 7 seconds before with an overload 100 per cent above the former setting of 150 amp. The curves in Fig. 1 bring out the fact that this breaker will act in almost exactly the same way for a setting 50 per cent above normal. Even with a setting of 200 per cent of normal the action is not greatly different.

Another important point in the time-lag device is the means employed to get a delayed action. The operation should be such that the time lag will depend on the current magnitude not only at the start of the action but during the whole operation. In a poor design after a heavy current starts the mechanism into operation, it may continue to operate even though the current will subsequently drop to a value lower than the tripping value.

Means for Opening Breaker on Failure of Voltage

Where the source of current supply is liable to occasional interruption a *no-voltage* feature is an essential adjunct to the circuit breaker for motor protection. The no-voltage device will open the breaker when the voltage falls to a low value. The direct-current motor is so constructed that it should be brought into circuit gradually, as by means of a suitable starting resistance. If, thereafter, the power supply is interrupted long enough to permit the motor to slow down materially or to stop altogether and is then restored with the motor starter in the running position, the motor receives current much in excess of its capacity, a condition which is likely to result in injury, not only to the motor, but also to the machine driven by it. The no-voltage circuit breaker prevents this by automatically disconnecting the motor from the line when, after the cessation of the power supply, the speed of the motor falls much below normal.

For manually-controlled, variable-speed motors the no-voltage circuit breaker is especially valuable, as it is not usual to embody the protective features afforded by this type of apparatus in the controllers employed for this class of motor. The no-voltage circuit breaker protects, more effectively than any other piece of apparatus, against the conditions incident upon interruption of service, because being especially designed for opening circuits, the final breaking points are of solid carbon. The main contacts are, therefore, not liable to burning and the instrument is free from the sticking to which other classes of switches are subject.

The circuit-breakers made by the Cutter Company equipped with the no-voltage feature are provided with a contact member for automatically disconnecting the no-voltage coil in advance of opening of the main switch member of the circuit breaker, thus protecting the coil from inductive discharge due to opening of the circuit breaker when carrying heavy current. Where no-voltage circuit breakers are employed it is good practice invariably to open the circuit by means of the circuit breaker or, where the circuit is likely to be opened by a hand-switch, to have one terminal of the no-voltage coil connected between

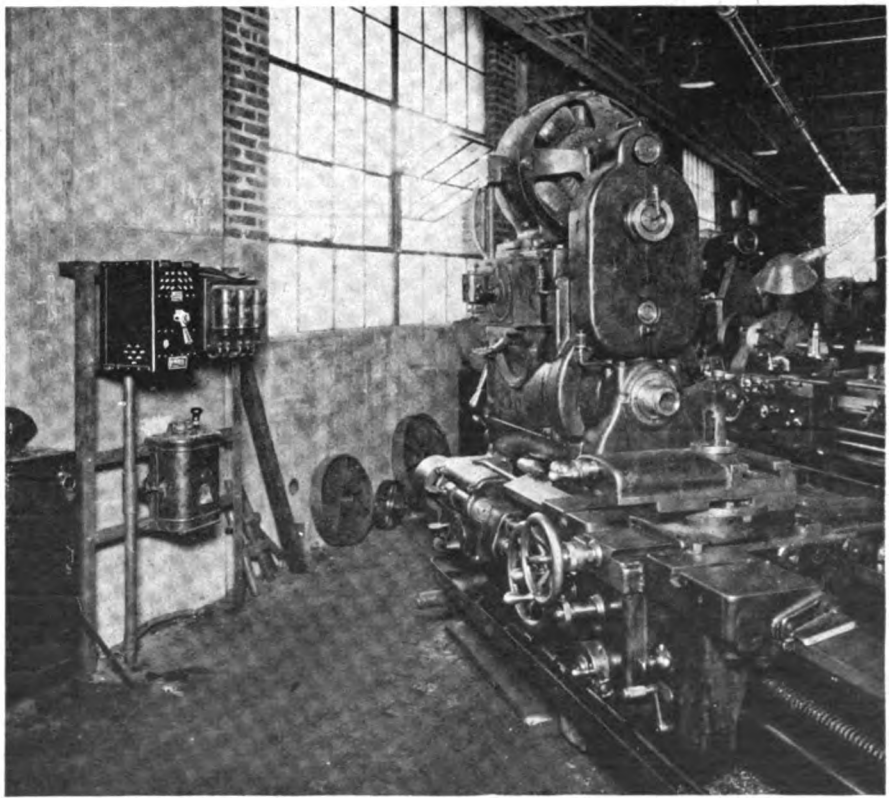


Fig. 4—Circuit breaker and automatic starter for a large lathe.
The circuit breaker has two poles that give full protection against overload, which is not afforded by the one overload coil of the starter when used on a grounded-neutral circuit.

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the hand switch and the source of current. The coil will thus be relieved of the discharge incident upon the opening of the switch, which discharge is likely to be of considerable volume if the circuit contains highly inductive apparatus, as for instance, series or compound-wound motors or magnetic brakes.

It is desirable to have the no-voltage device arranged so that it will be automatically reset when the circuit breaker is closed, thus avoiding the necessity of bringing the no-voltage armature into engagement with the magnet by hand while the other hand is used to close the circuit breaker.

Is a Single-Pole or a Double-Pole Breaker Preferable?

The question often arises in choosing a circuit breaker for direct-current motor protection: "Shall a single-pole or a double-pole instrument be used?" The motor operated from a two-wire system is quite frequently protected by means of a single-pole circuit breaker which, if one of the mains of the system is grounded, should be connected between the motor and the ungrounded main.

A properly chosen single-pole circuit breaker arranged in this manner will afford adequate protection to the motor, provided the operation of the instrument is in no way interfered with; but this condition is one which, owing to the human element, it is almost impossible to realize in practice. Usually, in fact it is required by the rules of the Underwriters that where a single-pole circuit breaker is employed, a hand switch be used in series therewith. When the circuit breaker opens, the hand switch should be opened before the circuit breaker is closed. Then, when the circuit is completed by the closing of the hand switch, the circuit breaker is free to respond should abnormal load conditions exist on the line. When, through haste or ignorance, the operator fails to observe this method of operation and the circuit breaker is closed without first opening the hand switch, if the overload condition still exists, damage to the apparatus or to the operator is almost certain to result. This is because the circuit breaker handle will be in the grasp of the operator and consequently its opening will be retarded, causing the arc to be maintained and allowing the continued flow of the excessive current.

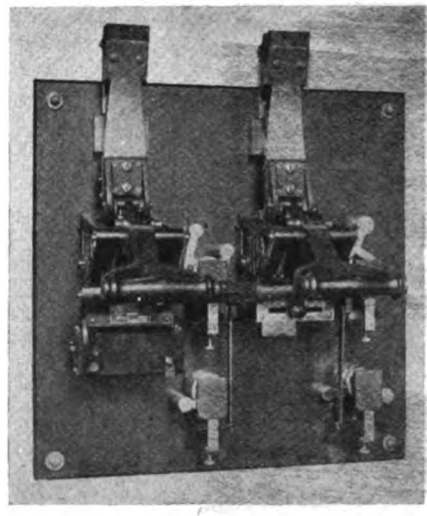


Fig. 6—Overload on any one of five motors trips this breaker.

This circuit breaker protects five crane-operating motors. An overload on any motor will cause the breaker to open. It has five overload devices, each having its independent adjustment with a range suited to the particular motor in the circuit of which it is connected. A shunt trip connected to a push button enables the operator to open the circuit at will. This is often a very desirable feature.

Accidents from this source are rendered impossible by the use of a double-pole instrument, the two switch members of which, while capable of being closed independently, are controlled by the same tripping mechanism. This type of apparatus is particularly adapted to the protection of motors whose control is likely to be in the hands of those whose knowledge of electricity is not

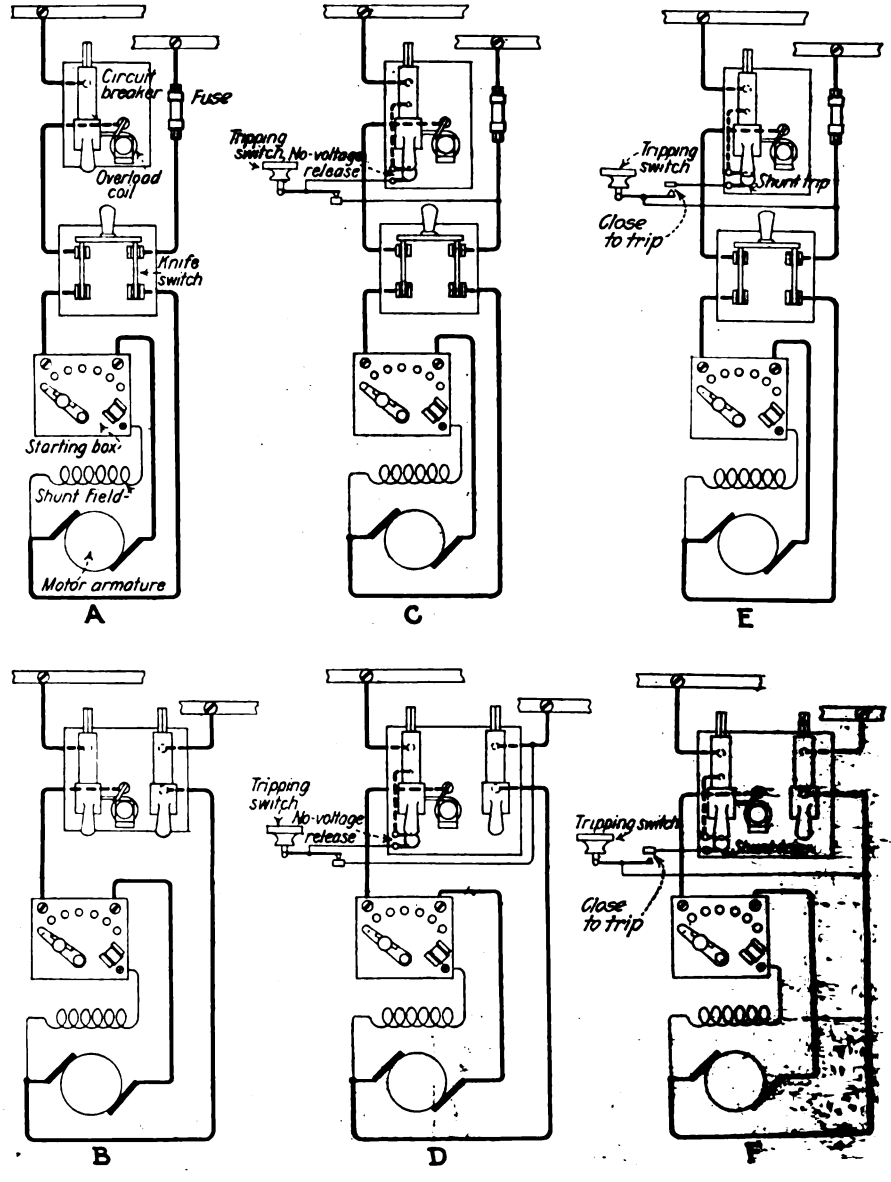


Fig. 5—Six ways of protecting d. c. motors with circuit breakers.

At *A*, *C* and *E* only one breaker is used for each motor, while at *B*, *D* and F two breakers are used. Where only one breaker is used a fuse and disconnecting switch must be provided in addition. Two methods of stopping the motor from a distance are shown at *C*, *D*, *E*, and *F*. A no-voltage release and tripping switch are shown in *C* and *D*. At *E* and *F* are a shunt trip and a tripping switch. When these methods of tripping are employed the control wire leading from the tripping switch directly to the line should attach to the grounded line wire. In the four cases shown the right-hand line wire should be the grounded one.

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Table I.—Capacity of Circuit Breaker Best Adapted for Direct-Current Motor of Given Size

Hp. of Motor at Rated Load	Ampere Rating of Circuit Breaker		
	For 125 Volts	For 250 Volts	For 500 Volts
½	4	....	....
1	8	4	....
2	20	8	4
3	30	12	8
5	45	20	10
7½	60	30	20
10	80	45	20
15	150	60	30
20	200	80	45
25	200	100	60
30	300	150	60
40	300	150	80
50	400	200	100
75	600	300	150
100	800	400	200

such as to insure proper handling of the apparatus. With each motor protected by such a circuit breaker the usual hand switch is rendered superfluous and the possibility of damage from overload is completely eliminated.

This condition is also secured by the use of the type of circuit breaker which cannot be closed or held closed during the continuance of overload on the circuit which it protects. Should an overload arise during the act of closing, the switch arm will instantly be released from the closing lever and the circuit will be broken regardless of any pressure which may be exerted upon the handle.

In three-wire installations the neutral main is usually grounded. For the protection of the motor operated from such a system a double-pole, double-coil circuit breaker is, therefore, necessary in order to insure immediate response in the event of accidental grounding of either the positive or the negative main. In the event of such a ground between the circuit breaker and the source of current supply, the overload coil, if on the side of the circuit thus grounded, will be short circuited and thus rendered ineffective. Where, however, the instrument is provided with two overload coils, one of the two will always be effective in opening the circuit in the event of the condition described.

How Remote Control of Circuit Breakers is Obtained

Circuit breakers may be arranged for either closing or opening from a distant point. The closing may be done magnetically, by a motor or pneumatically. Breakers are made embodying all these means of control. Sometimes it is desired to have a circuit breaker so arranged that it may be opened by an operator at a distant location. This may be done in two ways: (1) By installing a shunt-trip device and its circuit, and (2) by running the circuit from the no-voltage coil to the distant place.

By either of these methods the breakers may be opened at once from any number of points. The shunt-trip feature consists of a tripping magnet having a high-resistance coil normally out of circuit, but adapted to be brought into circuit either automatically upon the occurrence of any predetermined mechanical condition or by hand, as necessity may arise. This feature is especially useful in connection with crane motors, where, by the use of suitable devices for automatically closing the circuit of the shunt-trip coil, overtravel of the motor-operated hoists may be prevented. The movement of motor-operated draw bridges may conveniently be limited in the same manner. Motor-operated pumps may, by this means, be automatically cut out by using a float-operated switch to bring the shunt-trip feature into operation when the liquid in the tank supplied by the pump reaches the desired height. By similar means the motors operating air compressors may be automatically cut out when the desired pressure is reached.

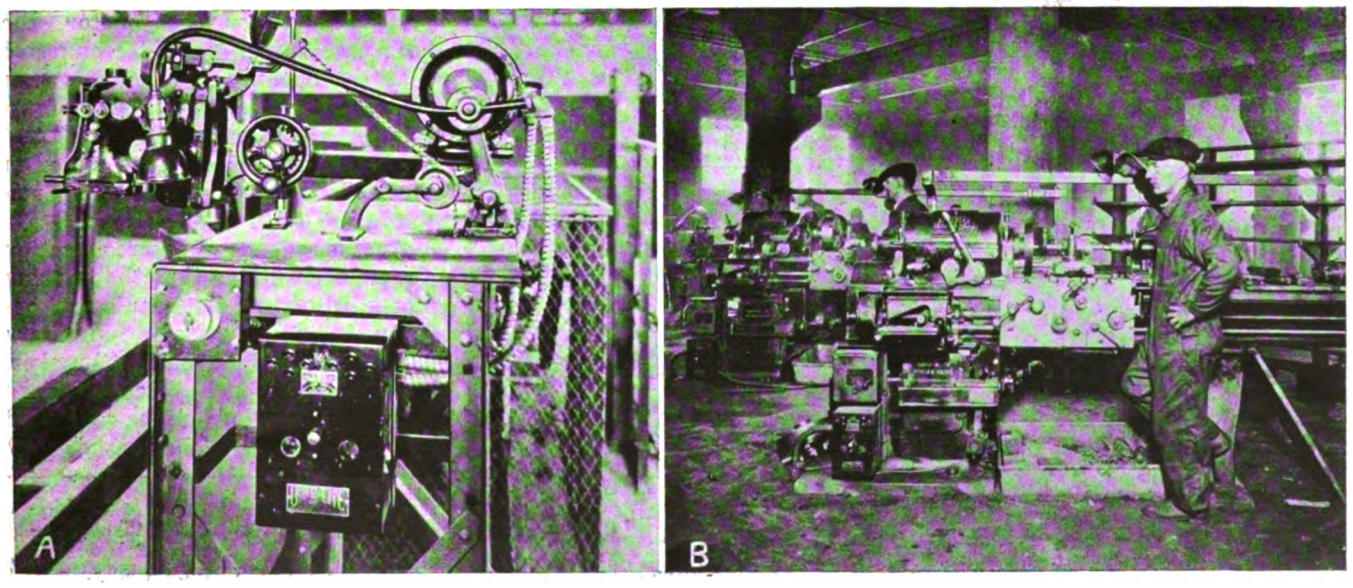


Fig. 7—Two cases where externally operated enclosed breakers are placed conveniently on the driven machine.

At *A* is a small breaker which protects the motor driving a sack-stitching machine. When the motor driving the lathe at *B* trips its breaker on overload, it may be started again at once as the operator does not have to leave his machine to reset the breaker.

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Where the material handled by the motor-operated machine is of a readily destructible nature it is often highly desirable that the operator shall be able to cut the power off instantly from any point about the machine under his care. This is made easy by the use of a circuit breaker having a shunt-trip feature with its coil connected into circuit through a number of normally open switches arranged in parallel and so located that one or more of them is at all times within reach of the operator.

Textile factories employing individual motor drive offer an admirable illustration of this class of service. Where each motor is protected by a circuit breaker with the shunt-trip feature the possibility of injury to employees is thereby greatly reduced, as ready means are thus afforded to cut off the power instantly from any machine involved.

Where motor-driven printing presses are employed the destructible nature of the substance handled makes it necessary that the operator shall be able to cut off the power instantly from any point about the press. In particularly exacting work the press is sometimes equipped with switches (in series with the shunt-trip coil) which are automatically closed by any irregularity in the run of the paper or failure to register properly. The prompt stopping of the press thus serves as a check against the production of imperfect work.

Any of these conditions may be taken care of likewise by means of the no-voltage device. The circuit from the no-voltage coil is extended to any points desired. Pushbutton or other switches are inserted in series with the circuit. These switches are normally in the closed position. When one of the switches is opened the current through the no-voltage coil is interrupted and its armature drops and opens the circuit breaker. Where these switches are desired at several points only a single wire need be run through each switch in series and back to the breaker. This method of control is good from the safety standpoint because any accidental open circuit in wiring or switches will cause the breakers to open and thus be brought to the operator's attention.

Two or More Motors Interdependent on Each Other

Where two or more motor-driven machines co-operate in handling the same material it is sometimes of the greatest importance that if one machine of the group becomes inoperative the others also will be put out of service. This condition frequently arises in connection with the motors operating traveling cranes, and coal- and ore-handling machinery. It is present also in certain manufacturing processes where the supply of material for each motor-driven machine depends upon the continued operation of the other machines of the group engaged in fabricating the same material.

Fig. 6 illustrates a circuit breaker which is especially designed for this class of service. In addition to the shunt trip it is provided with one overload coil for each motor of the group and a single switch member, the latter to be connected between the motors and the common source of supply. The result of this arrangement is that an overload on any one of the motors operated through this circuit breaker will cause the disconnection of all of them. In addition the shunt-trip feature affords a convenient means of opening the circuit breaker through hand-operated pushbuttons or by automatically actuated limit or stop devices.

Similar results may also be secured by the use of a separate circuit breaker for each motor, the breakers being so interconnected that the opening of one results in the opening of all. One way of arranging the breakers is to connect the no-voltage coils of one motor to the leads of the next preceding motor in the chain of operations.

Another means of interconnecting circuit breakers so that the opening of one will cause the opening of another, is by the use of an auxiliary switch mounted on the first breaker, as shown in Fig. 9. This auxiliary switch as shown should be connected to the *(Continued on page 563)*

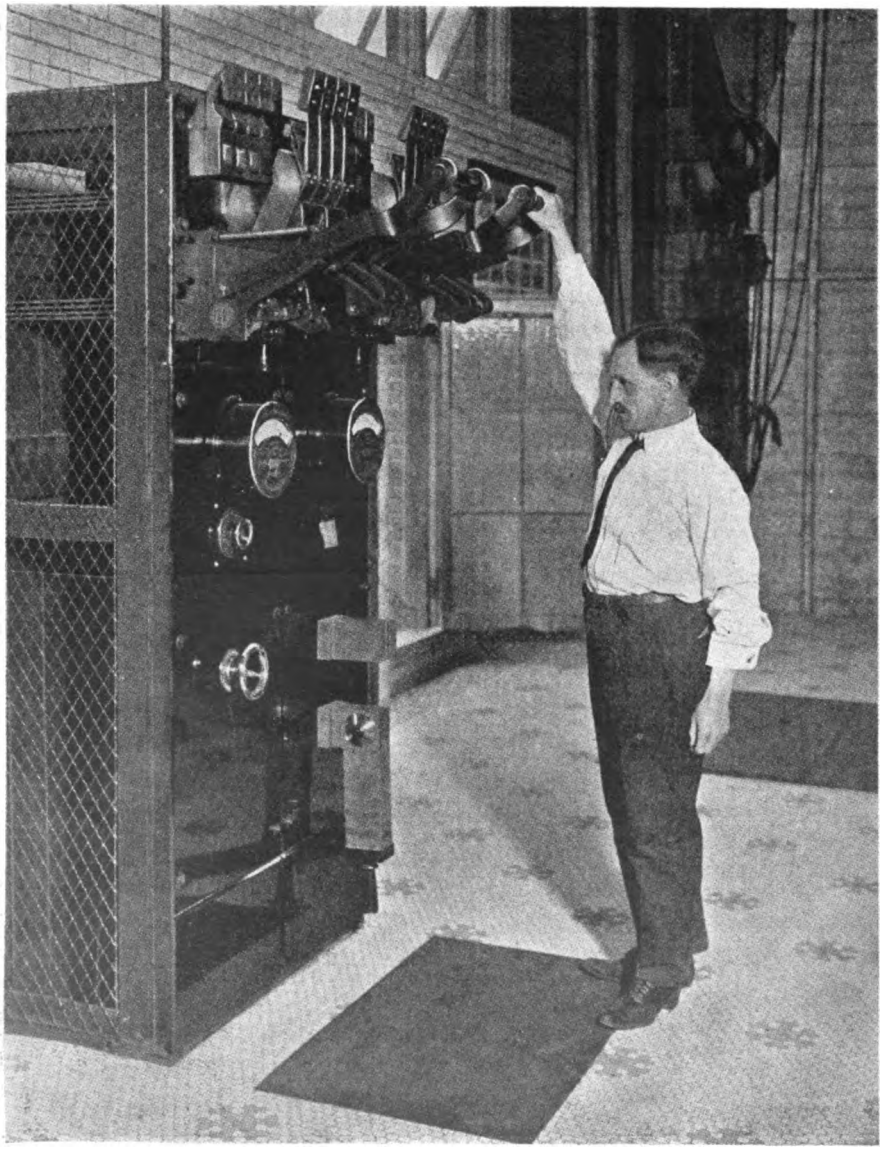
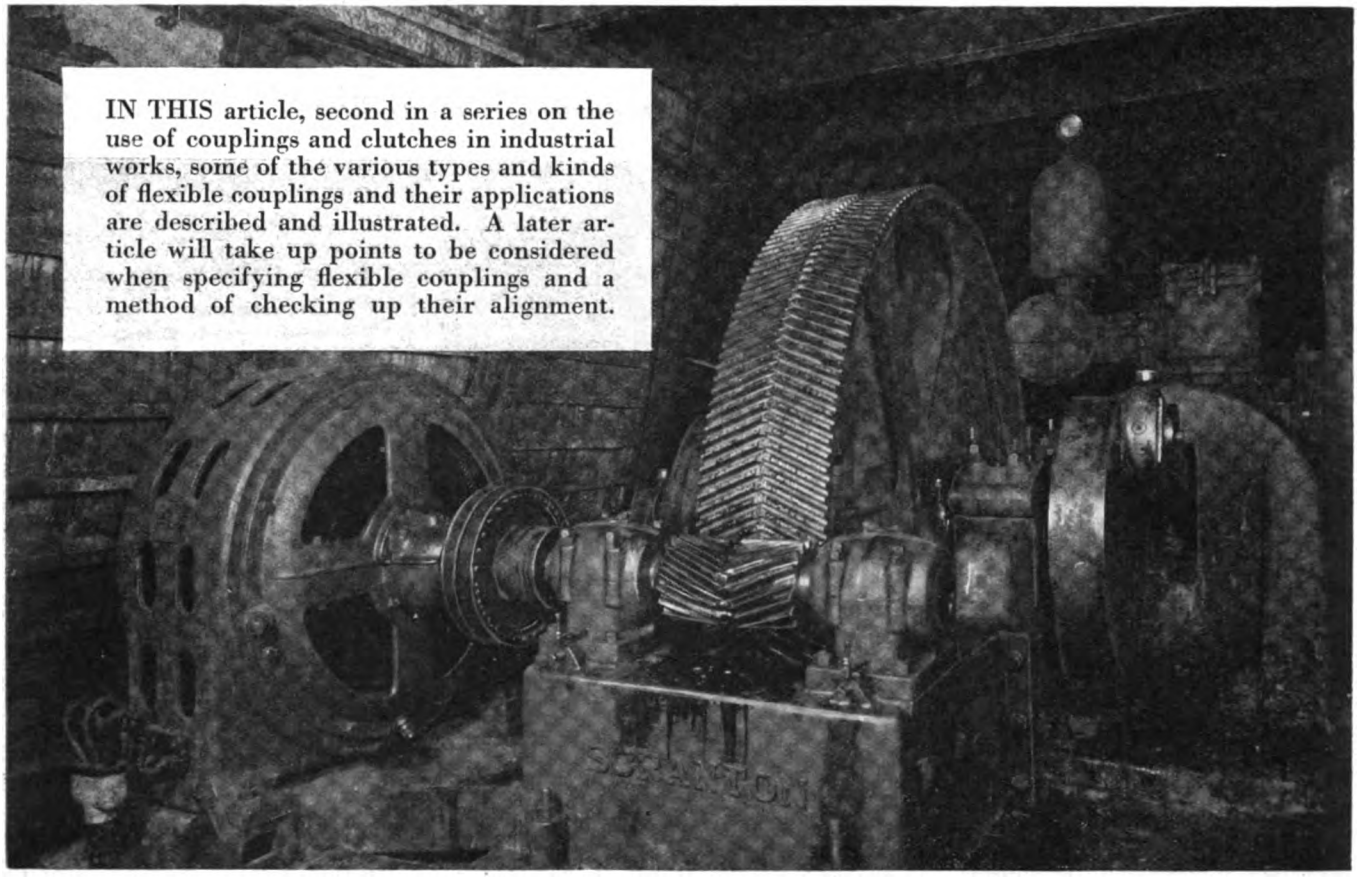


Fig. 8—Circuit breaker on 2,000-kw., 250-volt, two-wire direct-current generator panel in plant of Packard Motor Car Company.

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IN THIS article, second in a series on the use of couplings and clutches in industrial works, some of the various types and kinds of flexible couplings and their applications are described and illustrated. A later article will take up points to be considered when specifying flexible couplings and a method of checking up their alignment.

This flexible coupling connects a 450-hp. motor to the pinion shaft of a large plunger pump.

Points to Consider in Using Various

Types and Kinds of Flexible Couplings

To Provide a Non-Rigid Connection Between Shafts of Two Machines

By FRANK E. GOODING
Associate Editor, Industrial Engineer

RIGID flange couplings, which were discussed last month in the first article of this series, would make an ideal connection for two or more large machinery shaftings if it were not for the fact that they are too rigid and make no allowance for slight errors in misalignment or for the errors that come with wear of bearings, settling of frames or foundations, and other operating difficulties. With any misalignment and such a rigidly connected shaft, experience shows that some of the troubles to be expected are: Excessive shaft binding, loss of power through friction, excessive wear of bearings, difficulty of lubrication, and sometimes even broken shafts or couplings. Direct connection of machines is often very desirable and as a result various types of flexible couplings have been developed to fill this need, especially for high-speed operation.

Perfect alignment, if it were possible to be attained and kept, would be ideal. Builders of high-speed, direct-connected machinery such as turbines, line up shafts to within 0.003 or 0.004 in. On slower-speed machinery a greater allowance is usual and permissible. Hardly ever, however, on ordinary equipment does the misalignment exceed $\frac{1}{16}$ in. Continuous drives such as rolling mills and similar metal mill equipment are, of course, excepted in this statement.

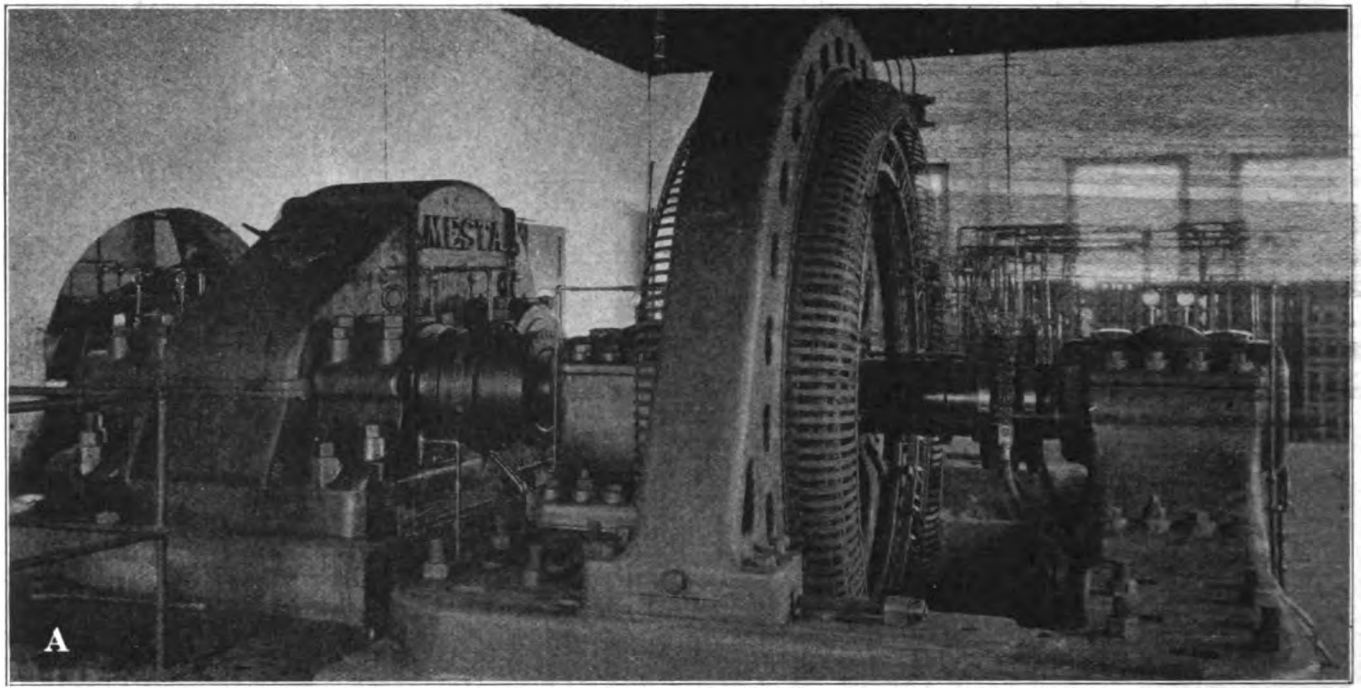
Misalignment, however, should not be permitted to continue but should be located by frequent check-ups on alignment and corrected. One of the most common complaints on flexible couplings arises from a mistaken belief that they will take care of any misalignment and do not need any attention after once installed. They do take care of a certain amount of misalignment, but operate much more satisfactorily, both as to the coupling and as to the machines, if maintained as nearly in perfect alignment as possible. It is not the function of a flexible coupling to compensate for careless or incompetent erection, nor for lack of reasonable maintenance attention.

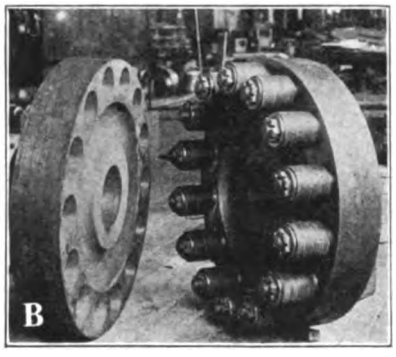
Misalignment may be either: (1) Parallel, that is, shafts parallel but out of center. (2) Angular, that is, with shafts in center but out of line. (3) A combination of both, with shafts out of line and also out of center. A misalignment made up of a combination of both types is probably the most common. When it is necessary to provide for

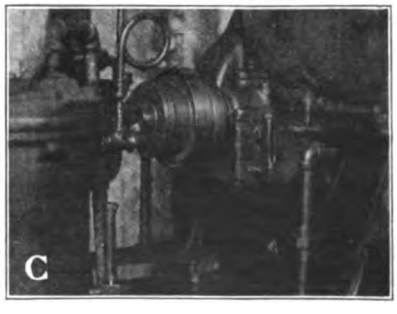
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Examples of Flexible Coupling Installations

Seven Typical Industrial Applications of Various Sizes







A—This flexible coupling operates at 240 r.p.m. between a 2,500-hp. motor and the pinion driving a steel mill.

B—A flexible coupling of the bushing type with flanges 40 in. in diameter.

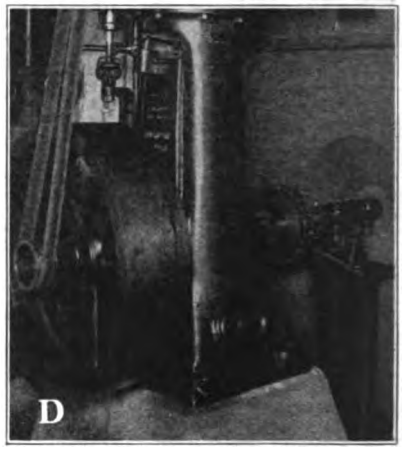
C—Here the flexible coupling is placed between an 80-hp. steam turbine, operating at 450 r.p.m., and the reduction gear, driving a forced-draft fan.

D—The circumference of the flange is cut with sprocket teeth and tied together by a chain on this engine drive to a ventilating fan.

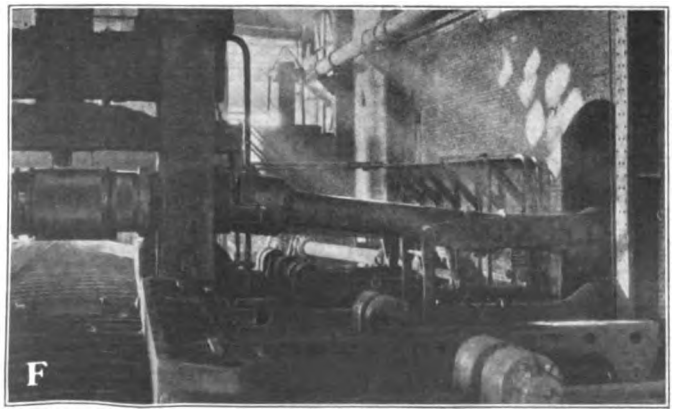
E—A close-up view of a large universal-joint type of flexible coupling used in steel mill work.

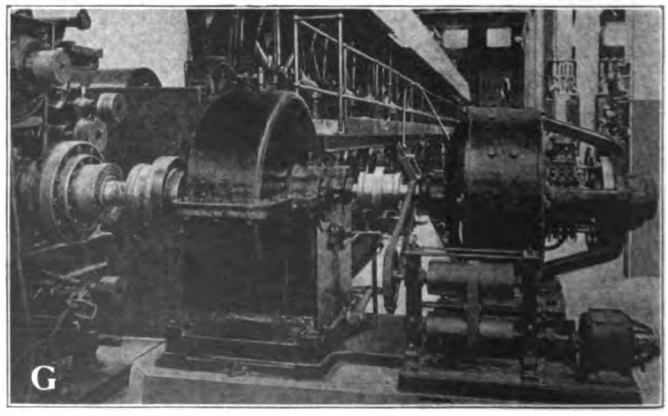
F—Here a pair of universal-joint type of flexible couplings are shown driving a 40-in. blooming mill at the Weirton Steel Company.

G—Four universal couplings of various sizes are used on a paper mill.









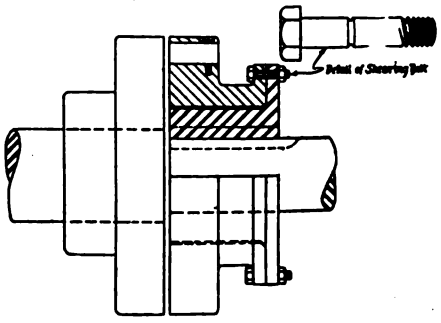
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the possibility of excessive misalignment, two couplings connected by a shaft may be used as shown in the upper of the two sketches at the left on page 532. A connection of this sort is sometimes used on rolling and blooming mills. For ordinary work this intermediate shaft is shortened down to a collar or floating ring as shown in the lower of these two sketches reproduced at the left of the page.

Rough Classification of Types of Flexible Couplings

There is a large variety of flexible couplings, many of which have special limitations as to size or the purpose for which they may be used. In general, they may be divided into: (1) Semi-flexible; (2) flexible; (3) universal joint.

In the classification of semi-flexible couplings are: (*a*) The familiar "Oldham" coupling which consists of two flanges, in each of which a keyway is cut across the face at angles of 180 deg. to each other with a central piece or disk having projections integral with it to fit into the cross keyways. (*b*) A flange coupling with pins solid in one flange and with clearance holes in other flange to receive pins, or the pins and clearance holes may be alternately arranged in both flanges. (*c*) Numerous other similar types and modifications which give flexibility of movement in but two directions except as looseness of parts may give flexibility in the third direction.



One method of putting a safety link into a flexible coupling.

Flexible couplings must be safeguarded against both overload and excessive misalignment. In case excessive misalignment may be expected a special type of coupling should be used. A shearing pin takes care of overloads.

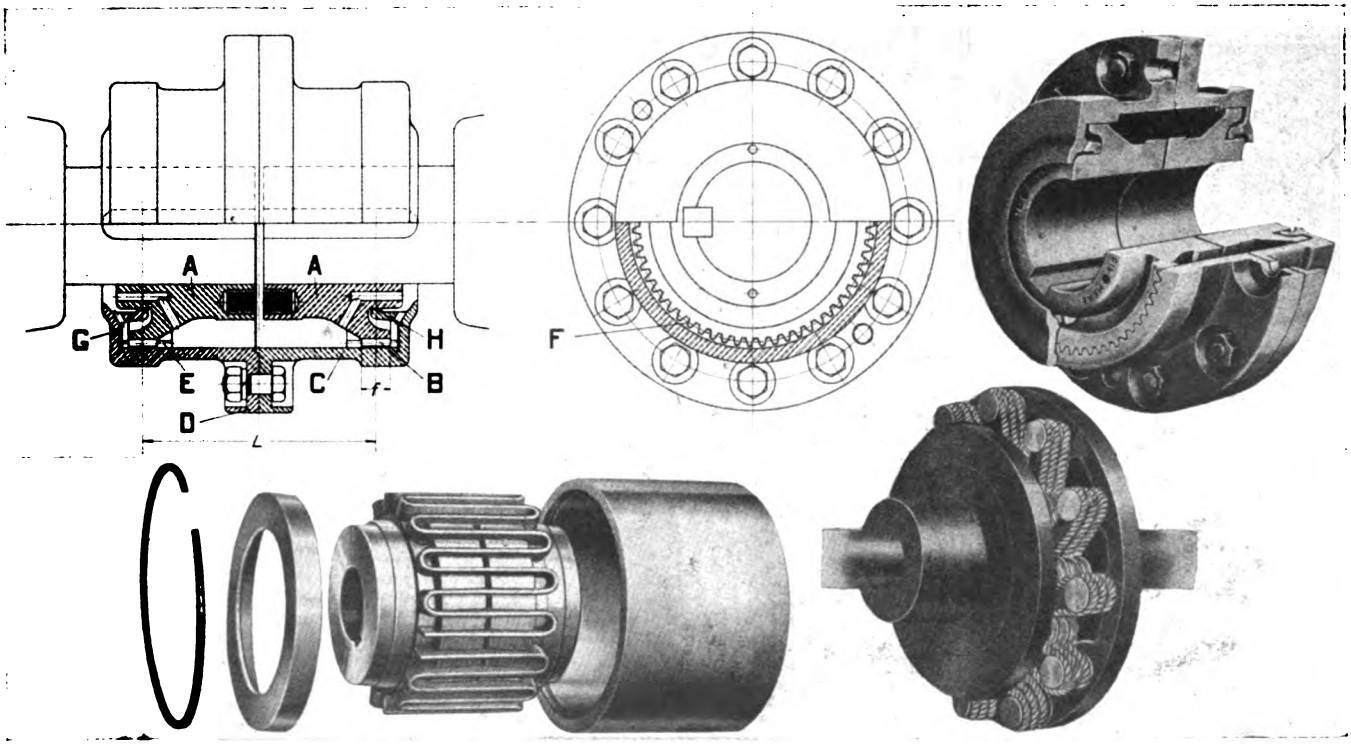
Semi-flexible couplings are usually used on light-duty work or on low-speed work where it is intended that the coupling will accommodate some slight difference in the endwise location of the two shafts rather than any movement after the shafts are in operation. If there may be any running misalignment it is usually found that such semi-flexible couplings are noisy and wear quickly. Most of these were among the earlier developments of flexible connections and are not so generally used for high-speed or heavy-duty work as are the newer types of flexible couplings.

The classification of flexible couplings comprises: (*a*) A flanged coupling with pins solid in one flange and with clearance holes in other flange to receive bushed end of pins. This is similar to the type (*b*) of semi-flexible coupling except that the pins are bushed with rubber, leather, fiber, or other similar material which permits a certain degree of flexibility. Frequently a metal bushing is placed around the pin to decrease the wear on the rubber or fiber bushing. (*b*) A coupling with projecting pins which are staggered and alternate on each flange and are connected with laced leather belts, rope, wire, or other material. (*c*) The coil spring coupling. (*d*) All-metal type couplings. (*e*) Such types as combine sliding movement and looseness of parts. (*f*) Types which combine sliding movement and flexure of materials.

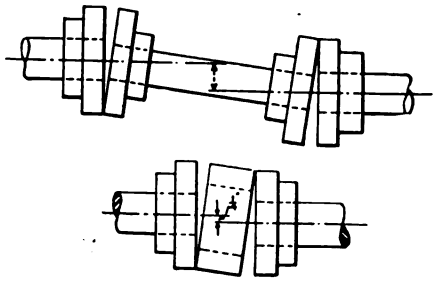
The bushed-pin is a common type of flexible coupling. In the smaller sizes this construction is inexpensive and while the bushings may need to be replaced often it is easily done

Three other well-known flexible couplings.

The three views at the top show a coupling which virtually consists of flanges with gear teeth cut in the circumference and meshing into a case containing internal teeth. This then operates with a self-aligning action somewhat similar to the self-aligning principle of bearings. As these teeth mesh in an oil bath the wear is slight and the coupling may be used in either forward or reversing motion. In the coupling in the lower left corner of the illustration the two half-flanges are tied together by tempered steel springs. The grooves in the flanges widen inward toward each other so that the spring fits closely in them only at the outer ends and so permits flexibility. The entire coupling is covered by a shell and operates in grease. The projecting pins on the two flanges in the coupling at the lower right are fastened together by an endless rope. This has a wide range of flexibility and is commonly used on blowers and exhausters.



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Two methods of taking care of parallel misalignment.

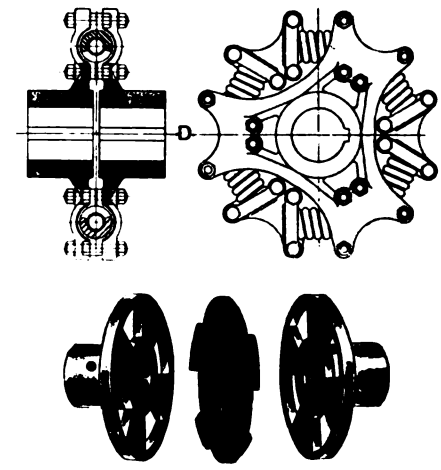
Where parallel misalignment is apt to be large, as in the upper illustration, a pair of couplings connected by a shaft may be used, particularly in rolling mills were couplings similar to universal joints are frequently employed. Where this misalignment does not exceed ¼ in. the shaft may be reduced to a collar about 13 in. long, as shown in the lower sketch.

and the cost is low. Sometimes the bushings are made of bronze in which case this type of coupling approaches the semi-flexible type with the pins and clearance holes as previously mentioned. Flexible couplings made with the flanges interlocking and using buffers of rubber or leather are of a similar type. Still another type of construction is made by recessing the flanges of the couplings and placing between these flanges a disk having leather or rubber lugs on it to fit into the flanges.

In some all-metal types of flexible couplings coil springs are used to join the flanges either in compression or in tension between interlocking arms of the two flange members. In other types the axis of the spring is in the same axis as that of the shaft. The operation of these is made more clear by the accompanying illustrations.

In addition some flexible couplings depend upon sliding movement between the coupling parts and a certain amount of looseness between these parts to accommodate the intended movement of the coupling. The "wobbler" type of coupling used for slow-speed work in rolling mills is a modification of this. Another type of coupling consists of flanges with sprockets on the circumference and with a chain loosely wrapped around the sprocket piece. Instead of the chain still another type of coupling uses a solid ring with internal teeth to mesh with the teeth on the external sprocket, as is shown in the cut on page 531. These teeth are filled with a lubricant to minimize the wear and as they are closely cut and meshed they may be operated in either direction, and, it is claimed, under reversing conditions.

Where sliding movement and flexure of materials is used to obtain the required flexibility for a given degree of misalignment, the life of the coupling is claimed to be longer than with rubber or fiber parts and with some types it is usually easy to replace the wearing parts.

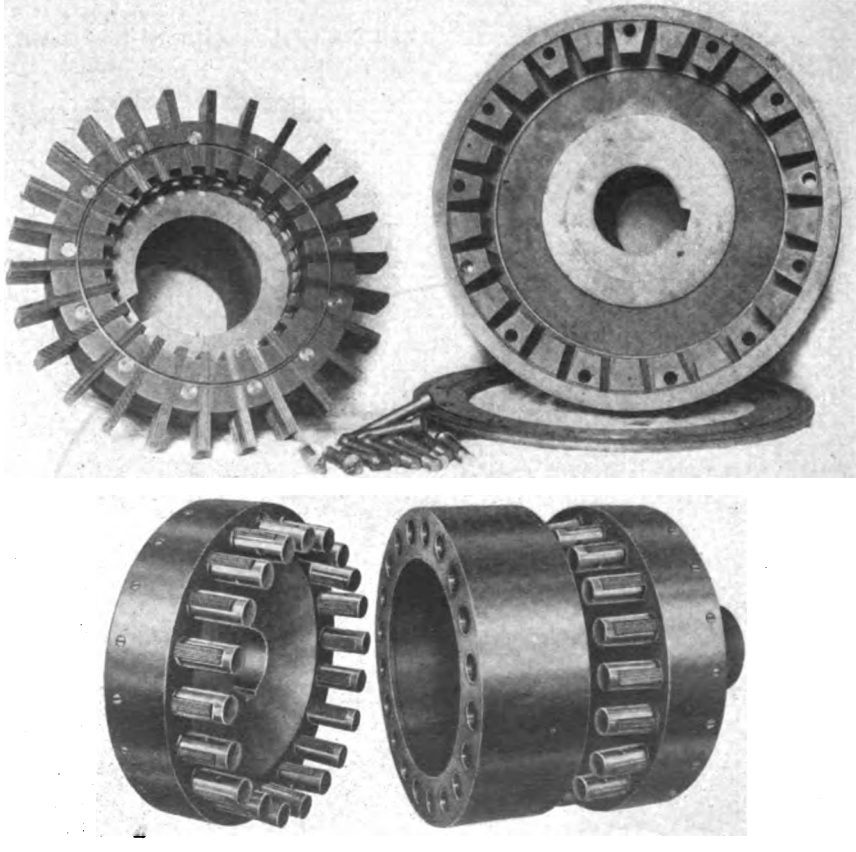


Two well-known flexible couplings.

In the upper coupling springs supply the necessary resiliency and flexibility. In other similar couplings rubber or other material is frequently used. The lower coupling uses a leather disk with projections which fit into recesses in the flanges.

In some cases, such as where it is necessary frequently to change armatures in emergency repair work, as in steel mills, some of these types of couplings are more easily dismantled than are others. Where such conditions are anticipated a half-coupling is usually fastened onto the spare armature shaft and the shift made with but little delay. In other types where the rubber or other resilient material must be renewed occasionally, some types are so designed as to be more convenient for disassembly and renewal. The frequency of this renewal varies according to the abuse, the amount of use, and the resilient materials used, as well as the amount of misalignment.

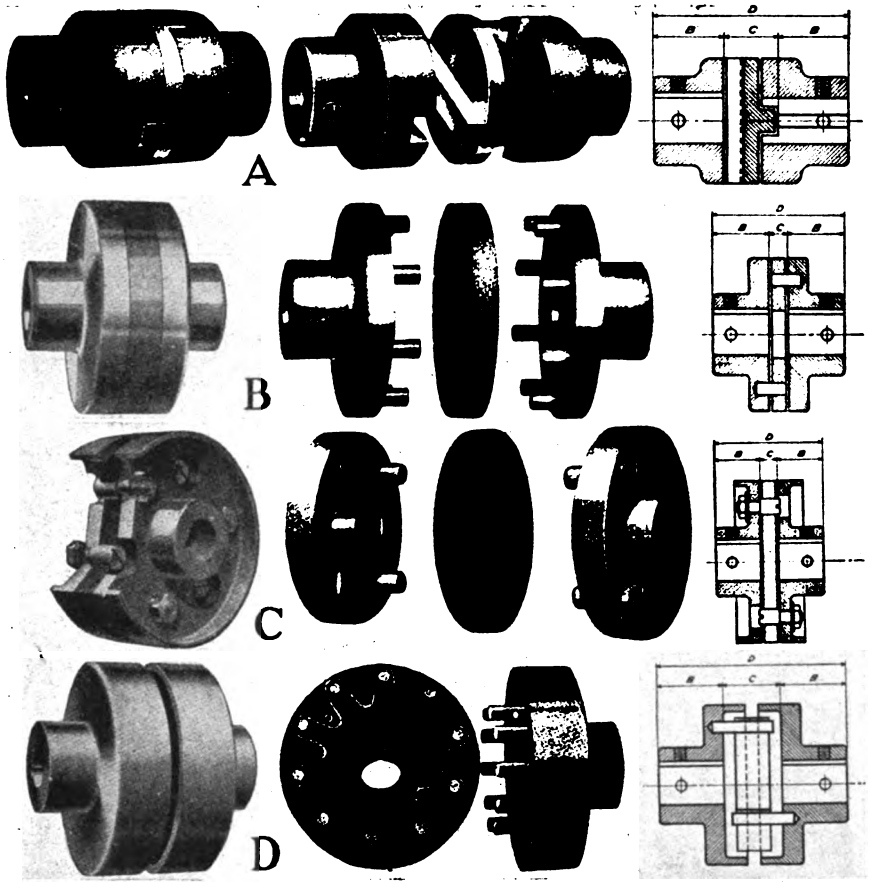
There are two separate and distinct applications of flexible couplings to act as safety devices, although these functions may be combined. One is for excessive misalignment which is covered particularly by some types of couplings and the other is for overload. In both cases the design should put the burden upon parts which can easily be replaced rather than upon the connected machines. A simple and inexpensive method of making a combination flexible and shearing



Two types of couplings depending upon the flexure of laminated steel segments.

In the upper illustration the flange at the left fits into that at the right, much as though it were an internal gear. This absorbs shock and allows for misalignment. The lower of the coupling is somewhat similar to the solid pin type flexible coupling except that the pins themselves are made of laminated steel sections and are flexible. This is a heavy duty, high-speed coupling, but a similar type is made without the central section.

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Here are four common types of flexible couplings.

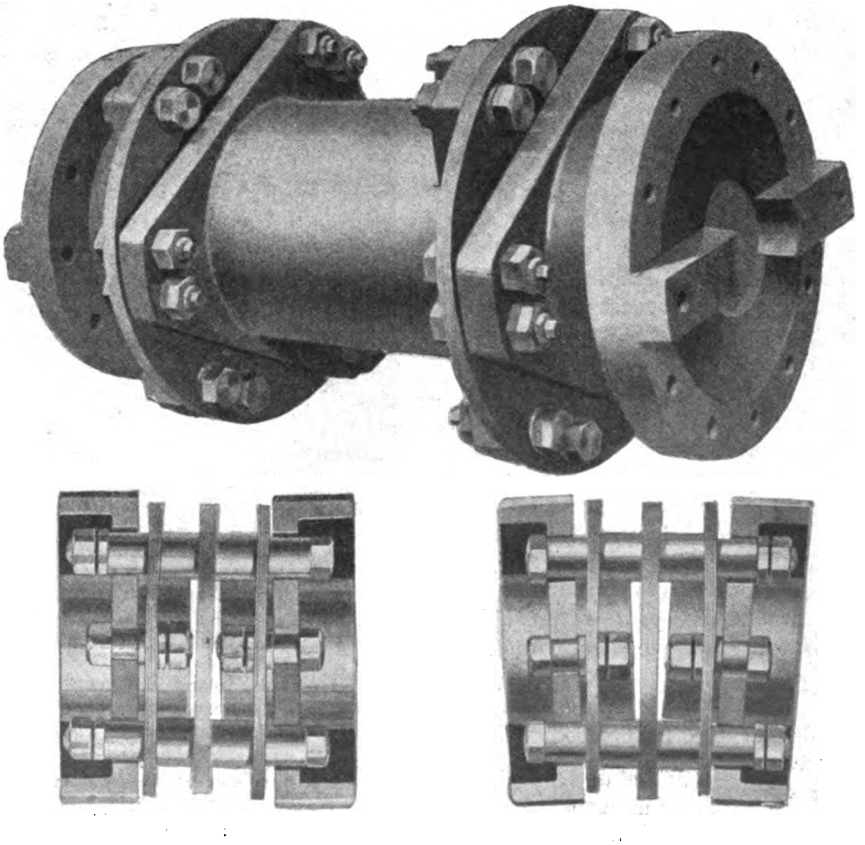
(*A*) This is an all-metal coupling with the flanges of cast-iron and the floating center piece of steel. This is of the "Oldham" type of semi-flexible coupling and is suitable for operation under heavy loads at slow speed and may be used for reversing service. (*B*) A coupling of the bushed-pin type where the pins fit into a fiber disk. The holes in the disks are slightly larger than the pins, which permits the coupling to automatically adjust itself for misalignment. It is commonly used for connecting motors, as it allows some endwise movement. (C) In this bushed-pin coupling a leather disk is used. The pins may be removed and the disk replaced without taking the coupling from the shafts or moving the connected machines. These bushed-pin couplings are not intended for low speeds or heavy torques. (*D*) In this coupling the steel pins are connected by special oil-treated endless leather belts. These are extremely flexible, absorb shock and vibration and are suitable for either high- or low-speed drives.

coupling is shown in the sketch on page 531, where one flange of the flexible coupling is loosely mounted on the hub of a flange which in turn is keyed to the shaft. This solid flange is bolted to the flange of the flexible coupling by bolts which have a reduced section as indicated.

In case of excessive overload of a predetermined amount, the bolt or bolts will shear before any serious damage is done to the connected shaft and the solid coupling will run free within the flexible coupling. After the trouble has been corrected new bolts are installed and the drive is again ready to run, at a negligible cost for new bolts and the shortest possible delay in production. This design also lends itself to the very quick change-over for a new rotor for one which may need repairing, or change for other purposes.

There is still another type of flexible coupling which in an analysis of its construction most closely resembles a universal joint. Most of these are constructed upon some modification of the original "Hooks" idea of one pair of fingers joining through a pair of pivot points and a block with another pair of fingers at right angles to the first one. Another type, shown below, consists of a number of fingers of one coupling member fastened at the end to a fiber or metal disk and alternately joined to the fingers of another shaft member on the other side of such disk. Both types are sometimes used on blooming and rolling mills where a large amount of power is transmitted at a large and varying angular misalignment.

These couplings are usually used to transmit *(Continued on page 564)*



A large and small unit of one manufacturer.

The upper coupling weighs 14 tons, has a capacity of 10,000 hp. at 100 r.p.m. and is installed at one of the plants of the Brier Hill Steel Company, Youngstown, Ohio. It provides for a parallel misalignment of ½ in. and endwise float capacity of 1 in. Here a central member is interposed between two end flanges and is connected to these flanges by laminated flexible steel disk rings which in turn are bolted alternately to the center member and end flanges. The two lower illustrations show a coupling of similar make built for high-speed service, as it operates under parallel and angular misalignment.

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IN THE SEPTEMBER issue of INDUSTRIAL ENGINEER a series of articles was started by Mr. Roe on laying out and checking up winding diagrams of induction motors. The second article in the October issue dealt with the checking up of three-phase windings when using short and long jumpers with star, delta and other connections. This article takes up the actual work which a repairman does with his hands and tools in making winding connections after he has checked up the diagrams and determined what connections to make. This series of articles should be used in connection with other articles by Mr. Roe which have appeared in issues previous to September of this year, on connections which are possible when making changes in induction motor windings.

Detailed Directions for

Stubbing and Connecting Windings

Of Induction Motors And an Explanation of Some Two-Voltage Windings

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company

ARTICLES by the writer that have appeared in INDUSTRIAL ENGINEER on connecting induction motor windings have referred for the most part to the diagrams that represent the windings. This article takes up the actual work which the repairman does with his hands and tools when connecting the motor. It tells how to stub the coils and how to locate and put on the jumpers between groups and the line leads. In addition there is also an explanation of windings which may be reconnected outside the motor for two different voltages. This is done by changing the connections of the external leads. Still another type of special winding, the two-speed and the four-speed winding, will be discussed in a later article in this series.

In connecting up a stator in which

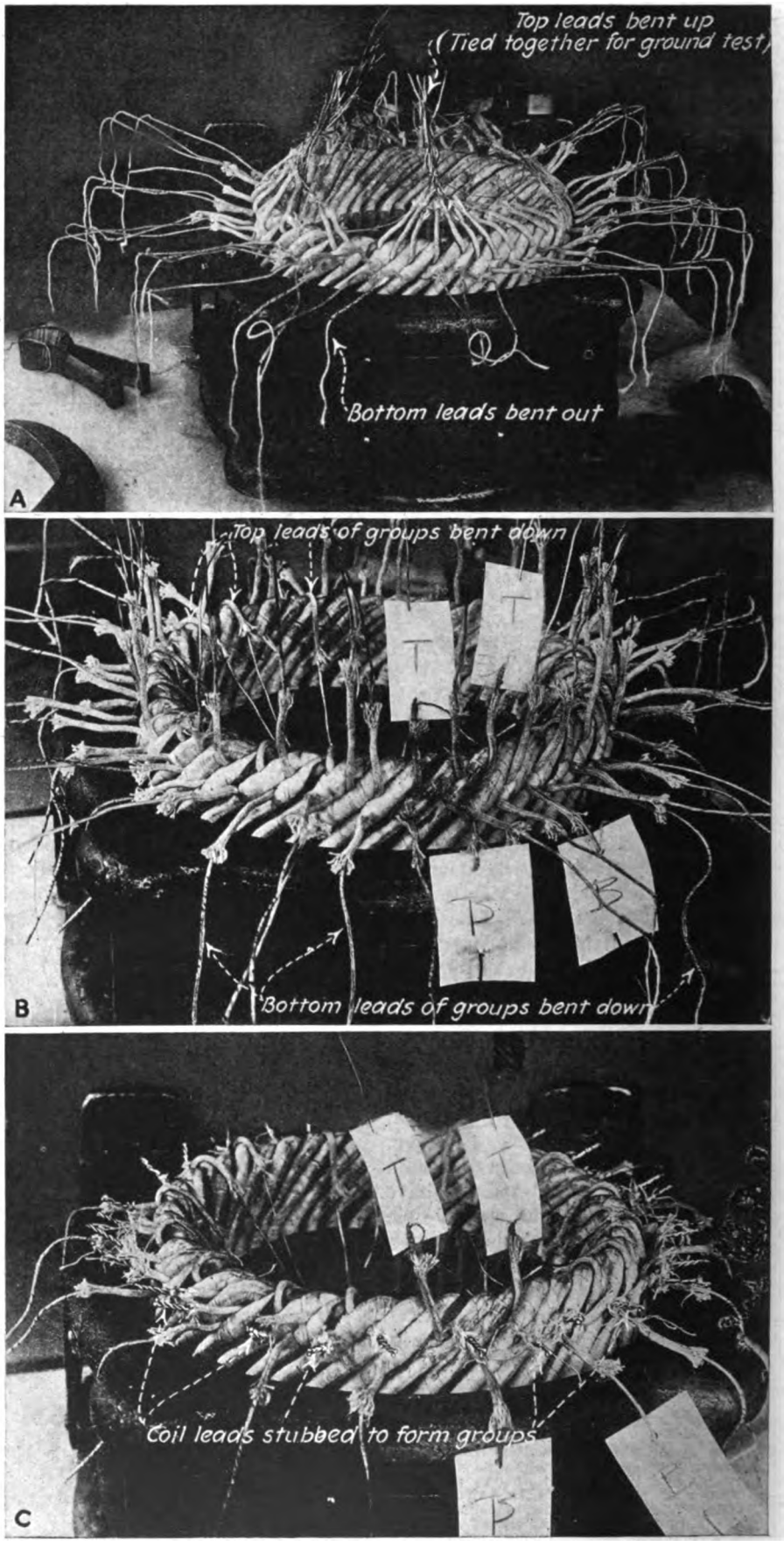


Fig. 1—Three steps in connecting the coils of a stator winding.

See Fig. 2 for three later steps in the process. This winding employs the coil leads for jumpers as well as for stubs. At *A* the top leads of the coils have been bent upward to separate them from the bottom leads, which have been bent outward. The top leads have also been tied together temporarily with copper wire preparatory to making a ground test. At *B* the leads which will be used as group leads have been separated from the other leads by being bent down, the top leads inside the stator and the bottom leads outside. At *C* the coils have been stubbed by twisting the leads together to form groups. With heavy-wire coils sleeves may be used in making stub connections.

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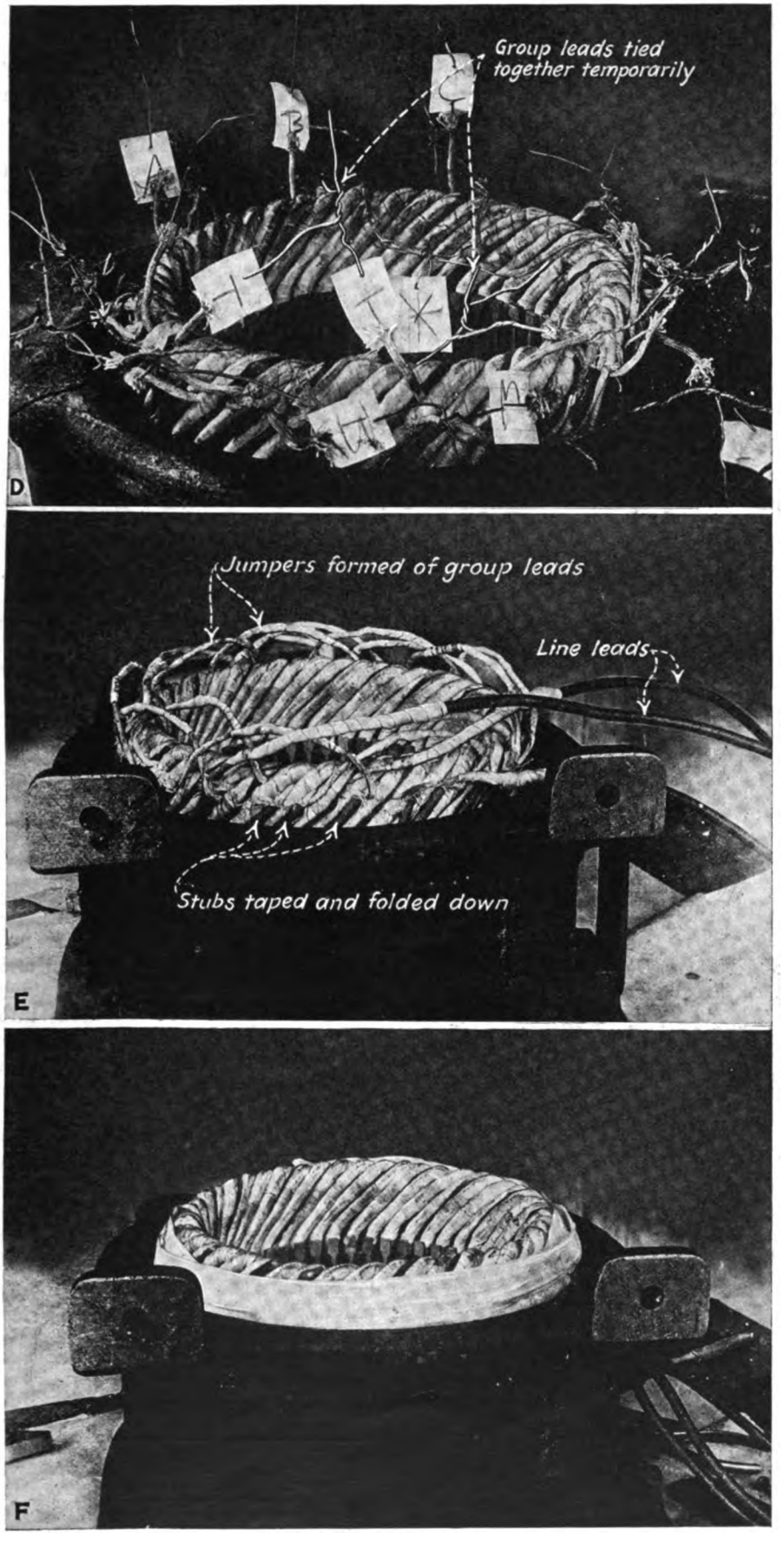


Fig. 2—Three later stages in connecting an induction motor.

Three earlier steps are shown in Fig. 1. At *D* the stubs have been insulated with tape and folded down. Where there is plenty of end room it is preferable to leave the stubs standing up as shown in Fig. 3. After the stubs are folded down in *D* the leads which form the jumpers are temporarily twisted together. They are afterwards connected by a Western Union joint and taped. Then the line leads are put on, as shown in *E*. The jumpers are then laid down and bound against the coils with cotton tape, as shown in *F*. The stator is then ready to be baked and dipped in clear varnish.

all the coils are in place, the first step is to separate the bottom leads from the top leads; then the coils are tested for grounds. After this the group leads are located, the coils in the groups are stubbed together and finally the jumpers between groups and the line leads are put on. The top leads are separated from the bottom leads as shown in *A* of Fig. 1. The top leads are bent upward while the bottom leads are bent outward. Then all the top leads are temporarily tied together after the insulation has been scraped off the ends. A convenient type of lead scraper is shown on the bench in *A* of Fig. 1. The leads are all tied together with a piece of bare copper wire which is put on tight enough to make good electrical contact with all leads. For making the ground test, an alternating-current testing transformer is used, one test lead being attached to the copper tie wire and the other lead to the motor frame. The voltage used in the test should be equal to twice the nameplate rating of the motor, plus 1,000 volts. For instance, a 220-volt motor would receive 1,500 volts. After this voltage has been held on for one minute without the breakdown of any coils, the insulation may be considered satisfactory.

The next step is to determine which are the group leads. When there is extra insulation between the phases, the position of the groups will have already been laid out and the group leads will be already determined. This extra insulation between the phases may consist of what are called phase-coils, which are covered with extra-heavy insulation and are put at the ends of groups. Another way in which this extra insulation may be furnished is by varnished cambric inserted between the groups while putting the coils in the slots. Fig. 1 shows insulation of this kind inserted between groups. Where such insulation is used, the group leads are found on each side of each piece of insulation.

On the other hand, if all the coils are insulated in the same way and there is no added insulation between groups, the position of the group leads must be determined. The method of determining the position of the group leads and the number of coils per group, and so on, was explained in the March, April, May and June, 1923, issues of INDUSTRIAL

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ENGINEER. Suppose, for instance, that we have an armature with fifty-four coils, all of which are insulated in the same way and there is no extra insulation placed between phases. If this is a three-phase, six-pole machine, there will be three coils per group. Then select a top lead and bend it down into the stator. Photograph *B* of Fig. 1 shows how the top leads are bent down. Count over to coil 3 (calling this first coil, coil 1); then bend the bottom lead of coil 3 downward towards the frame, thus forming one pole-phase group of three coils. The top lead of the next group, which is the top lead of coil 4, starts the second group and this is bent down. The bottom lead of coil 6 ends this group and this also is bent down. This process is repeated entirely around the winding until all the groups are formed.

Some winders use the number of coils per group as a lead pitch and pass around the machine twice, picking out all the top leads on the first round and the bottom leads on the second round.

After the group leads are picked out, the coils in each group are connected in series or stubbed. Ordinarily this is done by twisting the coil leads of the adjacent coils together. The top lead of one coil is connected to the bottom lead of the next coil. Photograph *C* in Fig. 1 shows how the coil leads are twisted together. The stubs are then wrapped with friction tape. After the stubs have been insulated they can, if the end room is scarce, be bent down and laid in the spaces between the diamond points of the coils, as shown in *D* of Fig. 2. When there is plenty of room, however, it is best to leave the stubs standing up, as shown in Fig. 3.

When the coils are made of stiffer wires, it is sometimes preferable to use sleeves for making the stub connections, instead of twisting the wires together. One type of sleeve is that shown in photograph *B* of Fig. 4. Another type is shown in Fig. 5. Fig. 4 shows a 4,600-volt, three-phase, eight-pole, 96-coil machine with four coils per group. In making up the coils, twenty-four of the coils have extra long top leads, and twenty-four extra long bottom leads. These are then placed in the stator, as shown in *A* of Fig. 4. The long coil leads are afterwards used for jumper connections. The stub connections are formed as in *B*. A small loop is left so that the stubs can be well insulated. They are taped with four half-lapped layers of varnished-cambric tape, each layer being brushed with clear baking varnish to fill in the pinholes caused by stretching the tape. After this they are wrapped with cotton tape, as shown in *C*.

In Fig. 5 is shown another type of connection used for stubbing and jumper connections, where very heavy wire is employed. These connectors are formed of sheet copper and consist of two round holes into which the wires slip, these being connected together by a cross piece of copper.

Insulation Needed on Low- and High-Voltage Motors

Voltage of Motor	Insulation To Be Used
110-220	Stubs: one layer friction tape. Jumpers: one layer treated-cloth tape and one layer friction tape.
440-550	Stubs and jumpers: one layer treated-cloth tape and one layer cotton tape. Fill tape with good baking or air-drying varnish.
1,100-2,300-4,600	Make stubs in loop form; insulate all joints with four half-lapped layers of treated cloth. Brush each layer with clear, amber baking or air-drying varnish. Afterward put on one layer cotton tape and fill with varnish as above.

How the Jumpers Are Put On

After the coils have been stubbed, the line and the star leads must be selected. If this winding has unequal grouping of coils the line and the star leads must be determined when the coils are divided into groups. If all the groups are equal, we may take either top or bottom leads for the line leads. In the case of Fig. 1, all top leads are used. Any top lead may be selected near the point where the leads pass through the motor frame. Call this lead a line lead and mark it with a tag, as shown in *D* of Fig. 2, or twist the wire so it may be identified later. The leads are then temporarily connected together by twisting as shown in *D* of Fig. 2. In a top-to-top connection, using short jumpers, as shown in Figs. 1 and 2, the short lead will be on the fourth

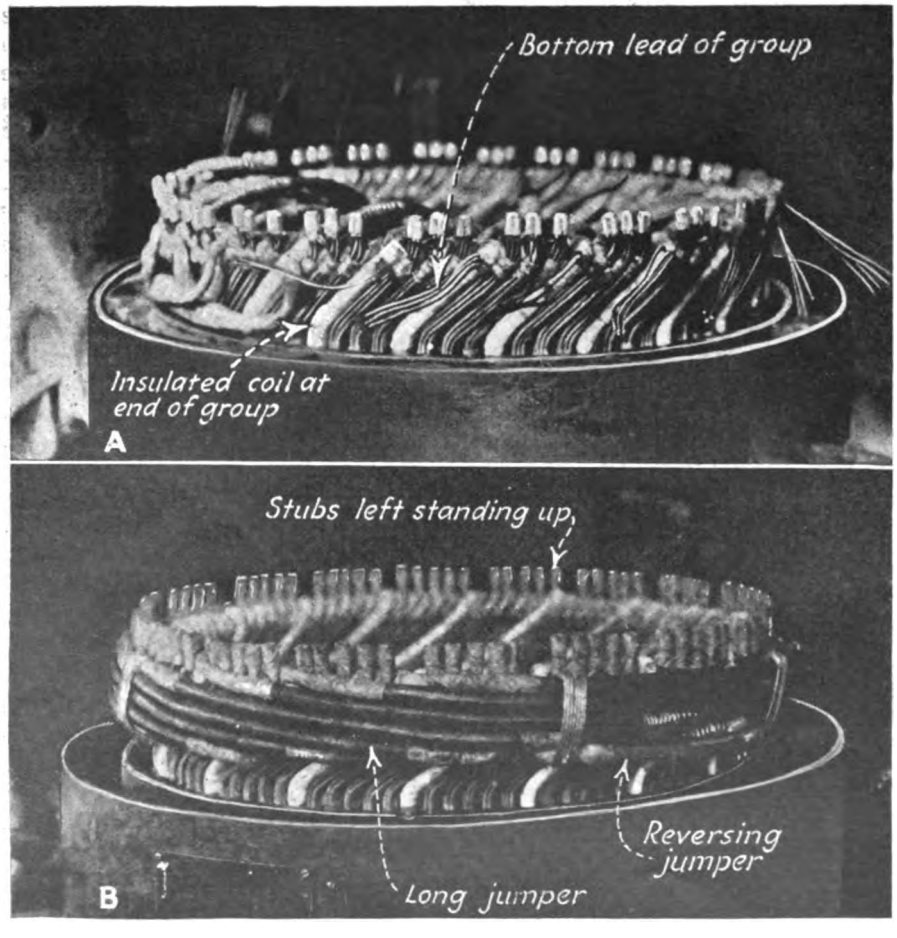


Fig. 3—Cable used for long type of jumper.
This shows the neat appearance which may be obtained when using the long jumper or top-to-bottom connection. The jumpers are rubber-insulated, stranded wire. The top connections are all made first, some of which are shown in *A*. Then all the bottom connections are made. The jumpers are tied together with cord at intervals, as shown at *B*. The stubs on these windings have been left standing up. It will be noted that the windings in *A* and *B* are not the same, although they are of the same kind.

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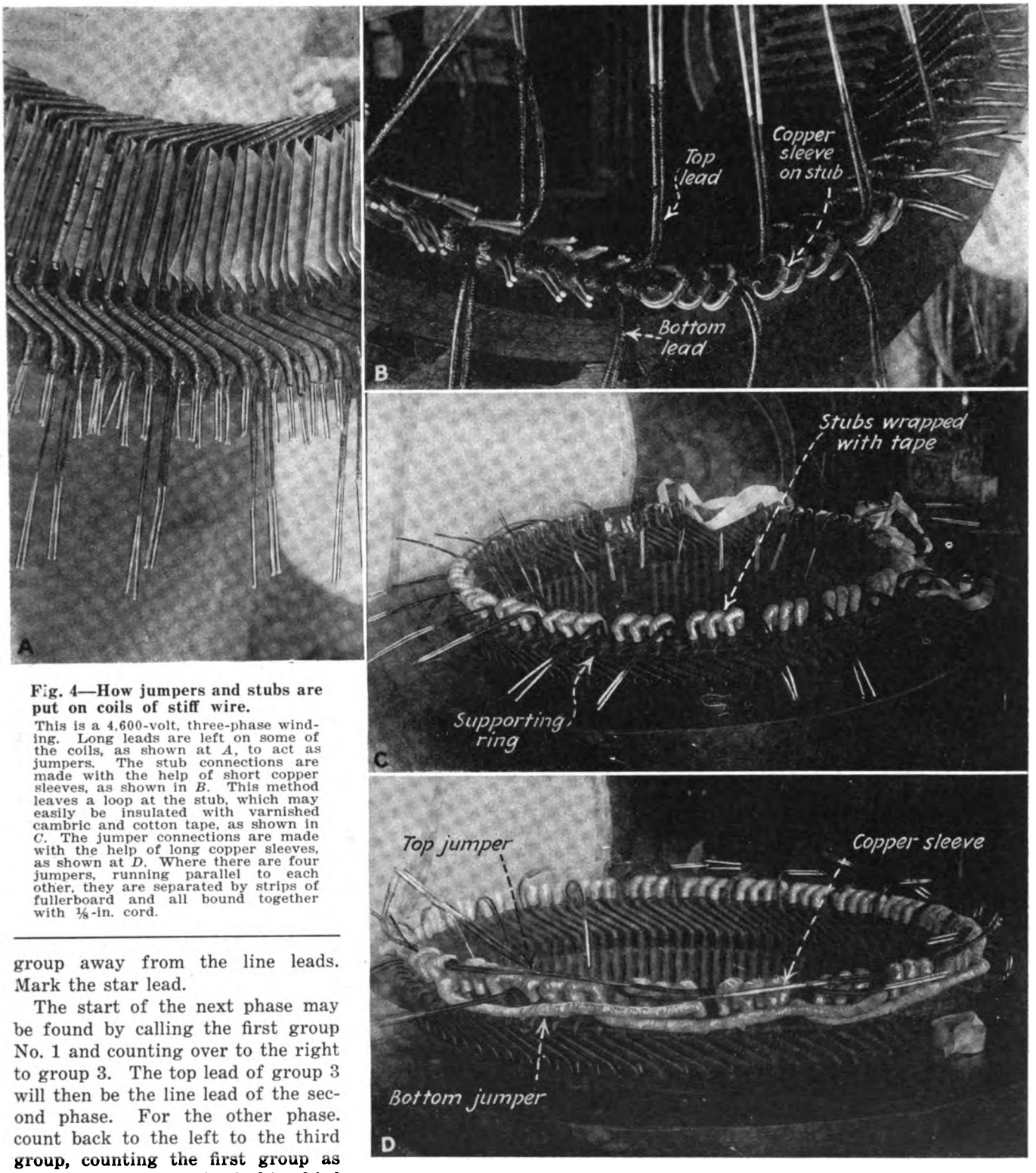


Fig. 4—How jumpers and stubs are put on coils of stiff wire.

This is a 4,600-volt, three-phase winding. Long leads are left on some of the coils, as shown at *A*, to act as jumpers. The stub connections are made with the help of short copper sleeves, as shown in *B*. This method leaves a loop at the stub, which may easily be insulated with varnished cambric and cotton tape, as shown in *C*. The jumper connections are made with the help of long copper sleeves, as shown at *D*. Where there are four jumpers, running parallel to each other, they are separated by strips of fullerboard and all bound together with ⅛-in. cord.

group away from the line leads. Mark the star lead.

The start of the next phase may be found by calling the first group No. 1 and counting over to the right to group 3. The top lead of group 3 will then be the line lead of the second phase. For the other phase, count back to the left to the third group, counting the first group as No. 1. The top lead of this third group will then be the line lead of the third phase. See photograph *D* in Fig. 2. This shows the three line leads which have been marked with paper slips and also the star connection which has been temporarily tied together and marked.

After these line and star leads are determined, the groups are connected in series. For the short-jumper type of connection the bottom lead of group 1 connects to the bottom lead of the fourth group to the right. Then the top lead of the fourth group will connect to the top lead of the fourth group to the right again. Continue this until the star lead is reached and repeat the same proceeding for each phase. Some winders connect all the bottom leads and solder and tape the connections and lay these jumpers in place. Then the top leads are connected and laid down on top of the bottom jumpers. This is called putting the jumpers down in two layers. When using small-wire coil leads for jumpers, employ the Western Union splice and solder each connection. Then tape the joint with one half-lapped layer of varnished-cambric tape and one layer of cotton tape. It is well to stick the ends of the cotton tape down with a little shellac to keep them from unwinding. Photograph *E* of Fig. 2 shows the jumpers of this machine all connected and taped. The leads also have been attached. In photograph *F*, Fig. 2, the leads and jumpers have been laid down and a few turns of twine have been

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applied to bind them together. The stator is next balanced out.

Then the stator is baked for four hours, at 212 deg. F., and dipped, while hot, in clear baking varnish to make the winding moisture-proof and oil-proof.

In case the coil leads which are used for jumpers are of heavy wire, copper sleeves may be employed as shown in *D* of Fig. 4. These long copper sleeves are put on and soldered and then the jumpers are insulated with a layer of half-lapped varnished-cambric and cotton tape. It may be noted that at some points there are four layers of jumpers. After the jumpers are all in place and insulated, treated fullerboard spacers are put between the jumpers at each point where there are four layers and the four are then tied together with a twelve-turn, ⅛-in. mason's cord band.

Fig. 3 shows an example of the long type of jumper. Note that in both *A* and *B* only one coil per group is insulated. This is the starting coil of each group. In some cases two coils per group are taped, in order to insure extra insulation between phases. Flexible cable is used for the jumpers in this winding. One jumper is made as a sample of the required length for the long jumpers and then the desired number of jumpers is cut. Both ends are skinned and tinned, after which they are attached to all top leads and soldered and taped. The jumpers are then bent into place and connected to the bottom leads, as shown in *B*. The long-jumper connection of this kind makes a very neat job.

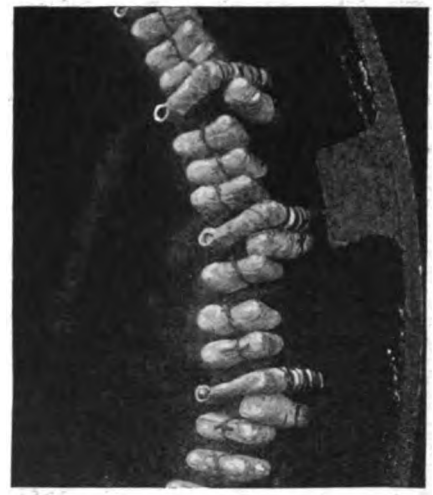


Fig. 5—Copper connectors used for stubs and jumpers on heavy wire.

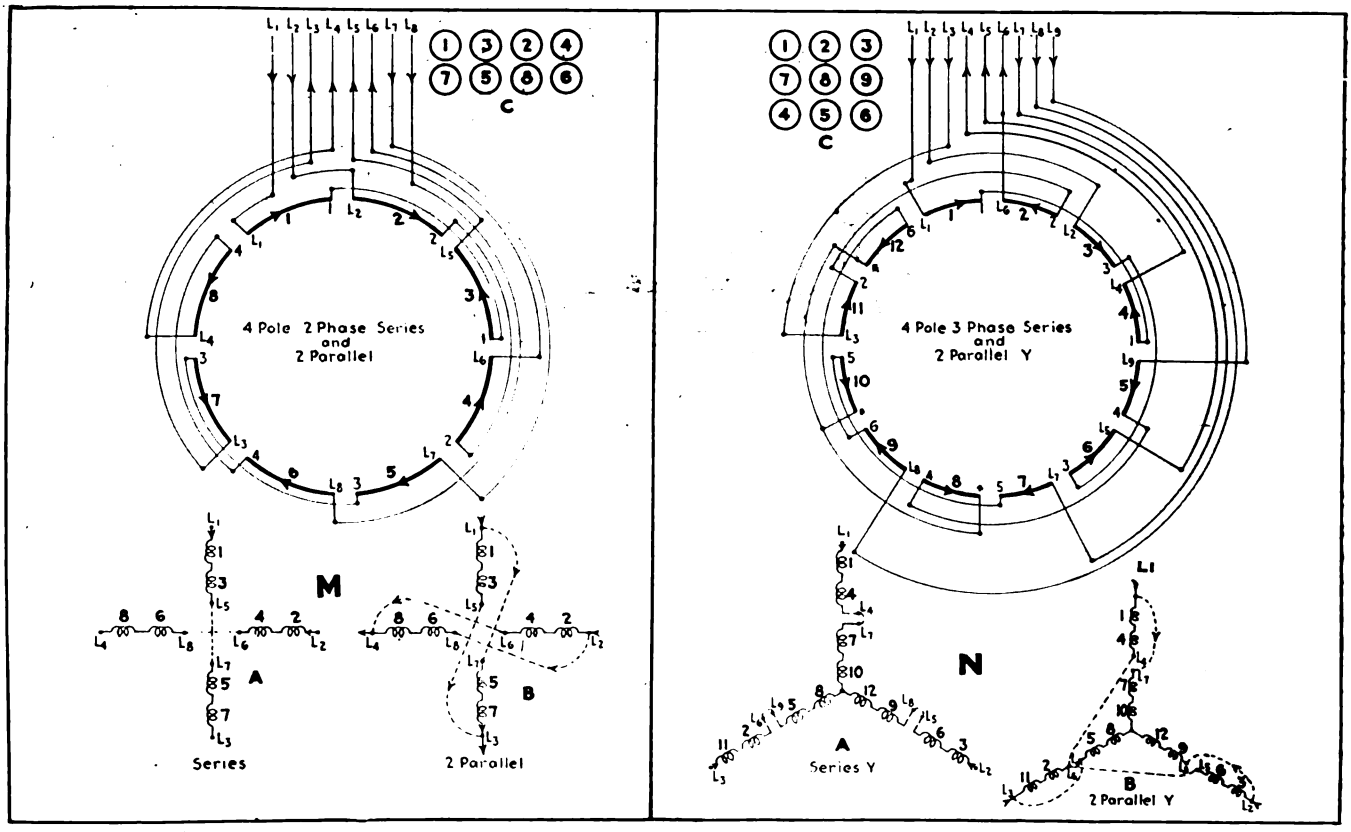
Fig. 6—Windings which may be connected outside the motor for two voltages.

The small diagrams *A* and *B* show how the series and the two parallel connections are made. The small circles at *C* show how the leads may be brought out to avoid crossing of leads outside the motor. For the two-phase, four-pole winding shown at *M* the series arrangement shown at *A* is obtained by making the following connections: *A*-phase lines to L_1 and L_3; *B*-phase lines to L_2 and L_4; L_5 to L_7; L_6 to L_8. The two-parallel connections shown at *B* are: one *A*-phase line to L_1 and L_7; the other *A*-phase line to L_3 and L_5; one *B*-phase line to L_2 and L_8; the other *B*-phase line to L_4 and L_6. For the three-phase, four-pole star winding at *N* the series connection shown at *A* requires that the line leads connect respectively to L_1, L_2 and L_3; L_4 to L_7; L_5 to L_8; L_6 to L_9. For the two-parallel arrangement shown at *B* connect one line lead to L_1 and L_7, the second line to L_2 and L_8, the third line to L_3 and L_9, and L_4 to L_5 to L_6.

How to Connect Windings for Two Voltages

There is a number of two-phase and three-phase motors that have the windings so connected that eight leads are brought out on a two-phase motor and nine on a three-phase. This is done to enable a quick change in voltage.

Drawing *M* in Fig. 6 shows a four-pole, two-phase diagram with eight leads. The object of this type of connection is to divide each phase into two sections, bringing out four leads, two from each section. Then the sections can be connected in series or in parallel outside the motor in a short time. In the small drawings, *A* and *B*, the schematic diagrams for these connections are given. Leads L_1, L_3, L_7 and L_5 form one phase with groups 1, 3, 5 and 7. The other phase consists of groups 2, 4, 6 and 8 and leads L_2, L_8, L_6 and L_4. The arrows indicate the direction of flow of current. At *A* the series connection is shown. This is accomplished by connecting L_5 to L_7, which forms the jumper between the tops of groups 3 and 5, and by connecting L_6 to L_8, which forms the



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jumper between groups 4 and 6. The two phases are not interconnected in any way. At *B* the parallel connection is shown. In this case L_1 and L_7 are connected to one line lead and L_8 and L_9 to the other line lead of this phase, thus putting groups 1 and 3 in parallel with groups 5 and 7. The other phase is similar. At *C* is shown one method of arranging the line leads at the motor terminal block to avoid crossing of outside connections.

At *N* in Fig. 6 is shown a three-phase star connection with nine leads brought out, there being three leads from each phase. In this diagram the ends of the second section of each phase are connected together inside the motor to form a permanent star. The schematic diagrams are shown at *A* and *B*. Note that the first section of each phase has two leads. At *B* the two-parallel star schematic diagram shows that L_4, L_5 and L_6 are all three connected together to form the second star connection but the two star connections are not joined together. This failure to join the two stars has no ill effects on the operation of the motor. Drawing *C* shows the way the nine leads are arranged for the least crossing when making external connections.

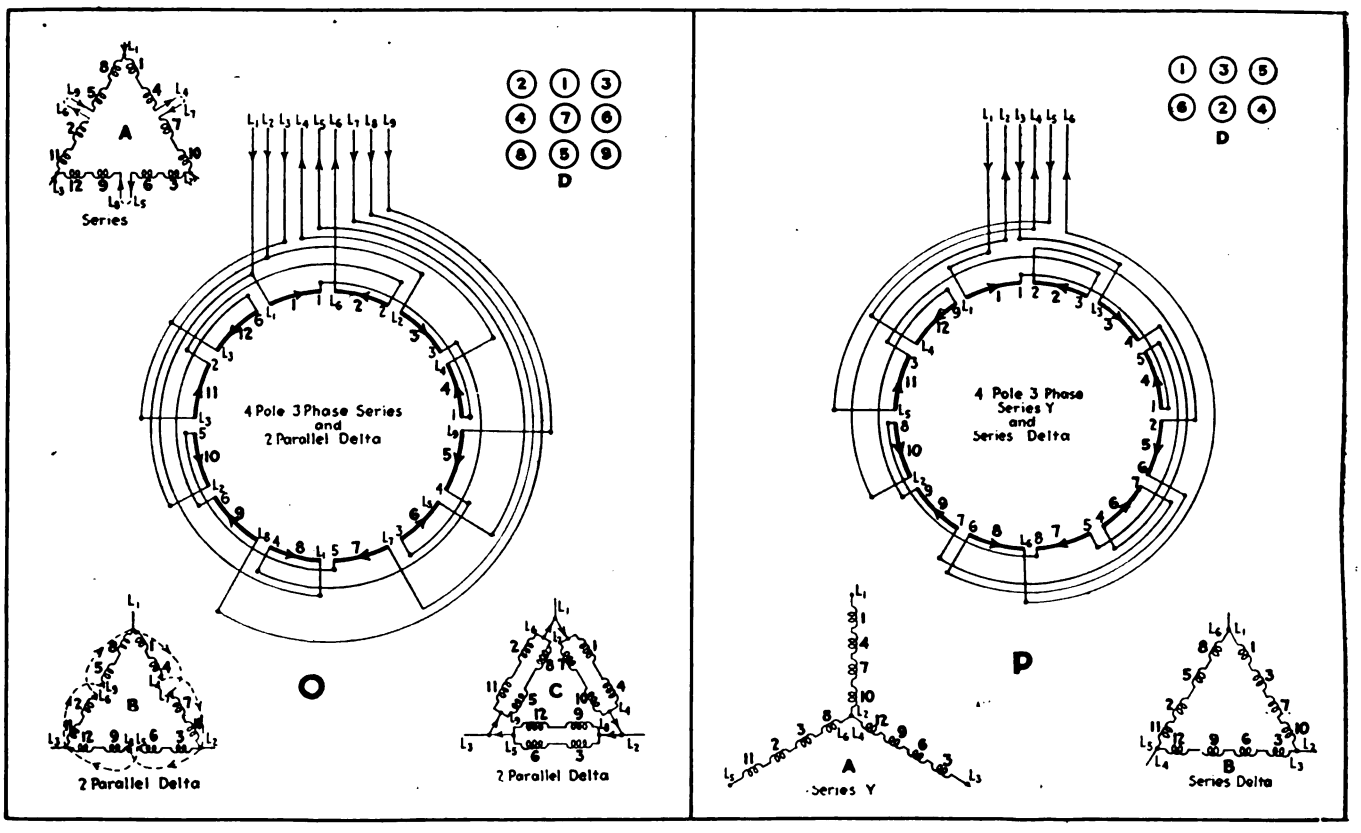
At Fig. 7 is a winding for series and two-parallel, three-phase delta connections, using nine leads. Each phase is divided into two sections as in the previous two cases, but in this diagram there are three leads that have two connections, L_1, L_2 and L_3. Each one of these leads has the beginning of a phase and the ending of a phase attached to it.

It will be noticed in all the special diagrams given here that the check used is the one that assumes the current flowing in on each lead, as this is the best one to use for line diagrams. This method is explained fully in the article on page 491 of the October, 1923, issue of INDUSTRIAL ENGINEER.

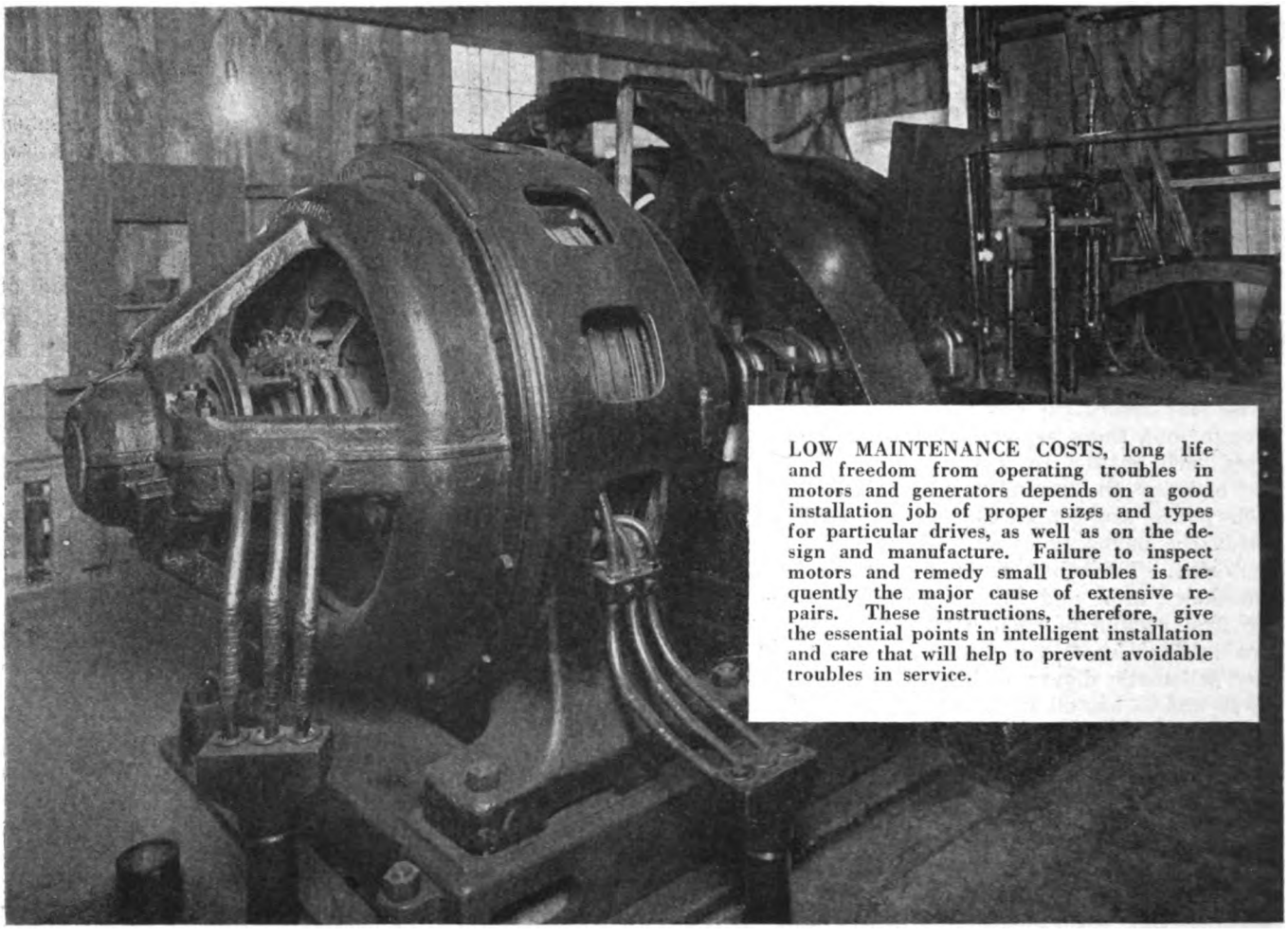
There are some three-phase induction motors that have the windings arranged so they can be used for the star-delta method of starting. In this method the winding is designed to operate at the line voltage with a series-delta connection. Then if a series-star connection is used to start the motor, it will have the same effect as reducing the applied line voltage to 58 per cent. Drawing *P* of Fig. 7 shows a four-pole winding which can be arranged for series-star or series-delta. In this case the phases are not divided, but the beginning and ending lead of each phase is brought out so that a star or a delta connection can be made outside the motor, as shown at *A* and *B*.

In case the tags become lost from the leads of double-voltage motors, the leads must be identified before the motor can be connected for operation. The following method of locating these leads requires a test lamp or buzzer and the removal of one end bell. The tests can be made in almost any location. In making the tests the various circuits are followed out and then marked with tags. Suppose the winding being tested is a four-pole, two-phase winding like that shown at *M* in Fig. 6. We know that such a winding is divided into four sections and that each section has two leads. Then the first step is to separate the leads into the pairs which are on the same sections. To do this hold one test lead on any one motor lead and test the other motor leads until one is *(Continued on page 562)*

Fig. 7 — A series-parallel delta winding and a star-delta winding. The small diagrams *A*, *B* and *C* show how the different connections are made. The small circles, *D*, show how the leads may be brought out to avoid crossing of leads outside the motor. For the three-phase, four-pole delta winding at *O* the series connection is obtained, as shown at *A*, by making the following connections: lines to L_1, L_2 and L_3, respectively; L_4 to L_7; L_5 to L_8; L_6 to L_9. The two-parallel arrangement, as shown at *B* and *C*, requires the following connections: one line to L_1, L_6 and L_7; the second line to L_2, L_4 and L_8; the third line to L_3, L_5 and L_9. For the three-phase, four-pole winding shown at *P* the star arrangement shown at *A* requires the following connections: lines to L_1, L_2 and L_3, respectively; L_4 to L_5 to L_6. The delta connection as shown at *B* requires that: one line connect to L_1 and L_6; the second line to L_2 and L_3; the third line to L_4 and L_5.



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LOW MAINTENANCE COSTS, long life and freedom from operating troubles in motors and generators depends on a good installation job of proper sizes and types for particular drives, as well as on the design and manufacture. Failure to inspect motors and remedy small troubles is frequently the major cause of extensive repairs. These instructions, therefore, give the essential points in intelligent installation and care that will help to prevent avoidable troubles in service.

Recommendations of Electric Power Club for

Installation and Care of Motors and Generators

From the Standpoint of Those in Charge of Their Operation and Maintenance

UNDER date of September, 1923, the Electric Power Club has issued instructions for the installation, operation and care of electric motors and generators. These instructions are similar in scope to the instructions for the care and operation of power transformers, published in the July, 1923, number of INDUSTRIAL ENGINEER and also issued by the Electric Power Club in pamphlet form. The Electric Power Club is an organization whose members are firms engaged in the manufacture of electrical power apparatus and control equipment. The purpose of the organization is to devise standards of practice and construction in application and design of electrical equipment, to discuss subjects of interest to the industry in which its members are engaged and to promote advancements and improvements in the production and use of electrical equipment.

In the introduction to the instructions for the installation, operation and care of electric motors and generators, the following comment is made:

"The life and successful operation of electric motors and generators depend upon their proper installation and maintenance as well as upon their proper design and manufacture. While motors and generators require less care than almost any other type of power apparatus, neglect of certain fundamental requirements may lead to serious trouble if not to the loss of the equipment. A wide distribution of information of this character is, therefore, important and these brief instructions have been prepared for the assistance of those responsible for the installation, operation and maintenance of electric motors and generators."

These instructions are given in full below:

I—GENERAL

Shipment.—All motors and generators are shipped completely assembled ready to set on the foundations, except those sizes which are limited by transportation and handling facilities.

Storage.—When machines are received, they should be kept in a dry, clean place and especially when they are put in storage and are not installed immediately.

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Machined parts are slushed or painted before shipment to prevent rust. If machines are to be stored for any length of time, those parts should be inspected periodically to see that rusting has not started and re-slushed if necessary.

A safe and reliable heating system should be provided to protect the windings of machines from alternate freezing and thawing. An electric heater with a thermostatic control is recommended when sufficient current is available.

Unpacking. — Unnecessary handling of machines at low temperature should be avoided as castings are more easily broken at very low temperature than at normal temperature.

When unpacking and handling machines the windings and other parts should be protected from damage.

Machines should be thoroughly inspected as soon as they are unpacked to see if they have been damaged in transit and to make sure that all parts, accessories, etc., are in the proper condition and position. All instructions and connection diagrams received from the manufacturer should be left with the machine.

If the windings of a machine have been exposed to low temperature, they should not be uncovered until they have had sufficient time to attain a temperature nearly as high as that of the room in which they are to be unpacked. If this procedure is not followed, the machine will sweat.

Handling.—Traveling cranes are exceedingly convenient in handling machines. Where stations or factories are not so equipped it is desirable, except for very small machines, for the user to build a crib or horse of heavy timbers for handling the machine. It will be found convenient and advantageous to retain the crib for further use.

Whenever practicable, a complete machine should be moved as a unit. This eliminates many possible troubles with windings, armature, slip rings, etc. Where machines are provided with eye bolts, these should be used for lifting in preference to slings. When lifting motor-generator sets, care should be taken not to spring the shaft by attaching the hooks or slings improperly.

Armatures.—When necessary to move the armature or rotor alone, the only safe method of supporting it while either moving or stationary is by slings or blocking under the shaft or by a padded cradle under the core laminations. The bearing journals must be protected so as not to mar the polished surface. The weight of the armature and field frame should not be allowed to rest on the base until the base has been leveled and grouted and the grout has had time to set hard.

The whole armature surface may be considered as subject to damage either to the bands, wedges, clips or insulation unless properly handled. Every precaution should be taken to avoid damaging any of the windings or other parts.

Commutator segments are very easily displaced and, therefore, an armature should never be lifted by passing a sling around the commutator. A spreader should always be used when lifting an armature to prevent the slings from drawing over armature band clips, collector rings, or commutator. Slings placed on the magnet frame must be so drawn as to avoid chafing the field coil insulation and the connections between coils. A rotor should never be lifted or supported by the slip rings.

If a wire rope is used for a sling, some waste or rags should be inserted between the sling and the machine to prevent marring the paint. In handling a complete machine, special care should be exercised to protect the oil gauges from damage.

Bearing Power of Soils

Soil	Tons Per Sq. Ft.	Authority
Good solid natural earth	4	N. Y. Building Laws
Pure clay, 15 ft. thick, no admixtures of foreign substances except gravel	1.75	Chicago Bldg. Ordinance
Dry sand, 15 ft. thick, no admixtures of foreign substances	2	Chicago Bldg. Ordinance
Clay and sand mixed	1.5	Chicago Bldg. Ordinance
Hard rock on native bed	2.5	Richey
Ledge rock	36	Richey
Hard pan	8	Richey
Gravel	5	Richey
Clean clay	4	Richey
Dry clay	3	Richey
Wet sand	2	Richey
Loam	1	Richey

Drying Out.—All electrical machinery not especially constructed to resist injury by moisture should be kept dry. If a machine has been exposed to moisture, the windings should be thoroughly dried before the machine is placed in service. Small machines can be baked in ovens and larger units can be dried by passing current through the windings. In either case, however, the temperature should be kept within a maximum of 85 degrees C. The temperature should be raised gradually and should be kept as nearly uniform as possible throughout the windings.

II—Installation

Location.—In order to permit satisfactory operation, the location of machines should be arranged to meet the following conditions:

1—Protection from moisture, escaping steam, dripping pipes, oil, acid, alkali, chlorine or other gases.
2—Protection from dust, dirt, lint or any other injurious substances.
3—Good ventilation and accessibility for cleaning and inspection with respect to the surrounding equipment. Motors should not be exposed to excessively high surrounding air temperatures, that is, where the ultimate temperature of the windings will be over 90 degrees C.
4—Sufficient floor space for a belted exciter if used.

**Foundation.*—Contracts for the purchase of electric motors and generators usually make the purchaser responsible for furnishing such foundations as may be required, and, in the absence of contract provisions, the following general information may be of value.

Foundations are generally made of concrete. The usual concrete mixture consists of one part cement, three parts clean, sharp sand and six parts crushed stone or gravel. This is sometimes expressed as 1:3:6. However, for quick work where quick setting is required, a 1:2:4 mixture can be used. Brick or stone can be set in a mortar consisting of one part cement and three parts sand. These foundations should be allowed to set at least two or three weeks before the machine is placed on them.

The size of a foundation is determined by the size of the machine and by the stress imposed by the machine. Any foundation must have sufficient area at its base to support its own weight and the weight of the machines. Some experience is necessary to design as light a foundation as will do, so it is better practice to make foundations with a generous factor of safety. Clean, sharp sand is considered to be a good bearing soil and the bearing power of different soils is given in the accompanying table.

No general rule can be given for the proper weight of a foundation,

*This information is particularly applicable to large machines. For small machines, wood or iron framework is usually used but unless substantial ironwork or heavy seasoned timbers are used, the machines are liable to get out of alignment and vibrate.

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but usually if the foundation is large enough to include all of the foundation bolts of the machine and extends to a good bottom, it will be sufficiently heavy for the purpose.

In most applications of large machines, the hollowed-out type of foundation is required. The position of the holding-down bolts is shown on the outline drawings of the machine and a template should be used for laying out the location of all the foundation bolts. In order to permit a slight variation in the position of these bolts, they should be located in iron pipes with an inside diameter at least 1 in. larger and preferably 2 in. larger than the diameter of the bolts. (See Fig. 1.) When the machine is in its exact location, the iron pipes should be filled with concrete or grout to the top of the foundation.

Bolts can also be cast in solid and foundation washers can be used on the lower ends of the bolts to secure them in the foundation. Ordinary round building washers, pieces of steel plate with holes punched through their centers, pieces of angle iron, etc., are sometimes used but standard foundation washers are better, as they are designed to prevent the nut from turning on the bolt. With large machines, it is desirable to have pockets in the concrete large enough to take the plates. The foundation bolts and plates can be hung in the holes and the holes filled when grouting the base. This insures a good bond between the foundation and the grout, in and under the base, and the proper setting of the foundation bolts.

Good grout is a mixture consisting of one-half clean, sharp sand and one-half cement. It should be made thin enough to flow readily. Before pouring the grout all dust and dirt should be cleaned off and the foundation wet down thoroughly. It is advisable to use a slow setting cement with large castings, otherwise the temperature rise of the setting grout may cause distortion of the casting. Old cement sets slower than new.

Where assembled machines are mounted on bases, the base should be carefully leveled before being grouted in. An average distance of 1 inch should be allowed between the top of the foundation and the bottom of the base for grouting. If this distance is too large, there is a chance of the grouting shrinking away from the base.

To grout the base, build a low dam around the inside and outside and float in the grout mixture to a height of one-quarter inch above the lower face of the base. If the grouting is too deep, it will make it difficult to subsequently remove the base if desired.

Bases of machines shipped disassembled should be also grouted in but the grout must be given sufficient time to "set hard" before the stators and pillow blocks are put in place. This work should be done under the supervision of an expert on the lining up of machinery.

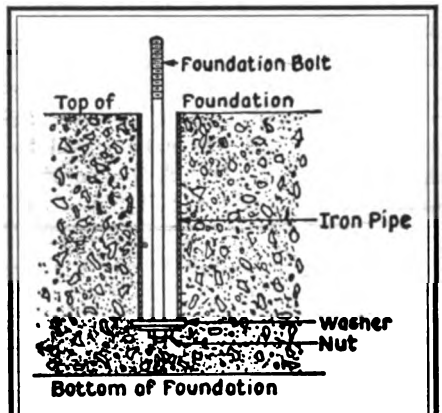


Fig. 1—Method of locating foundation bolts, using a 1-in. bolt and 2-in. or 3-in. pipe.

Motor and generator bases are not supposed to carry any weight when unevenly supported. To prevent distortion, therefore, they should be carefully leveled by means of leveling wedges and grouted before any weight is placed on them.

Erection.—Machines must be lined up on their foundations, so that the driving and driven shafts are parallel. Driving and driven pulleys must be in line so that the belt will run true. Driving pinions and their gears must mesh accurately. If the machines are direct connected the shafts must be in line. Full assurance that the pulleys are properly aligned can be obtained by temporarily installing the belt and turning the pulleys by hand where this is possible. After the machines have been accurately aligned, the slide rails, bed plate, or the machine itself (as the case may be) must be bolted rigidly to the foundations.

Wall and Ceiling Mounting.—Motors or generators intended for floor, wall or ceiling mounting have end shields or bearing housings which can be turned through 90 or 180 degrees. Machines are shipped for floor mounting unless otherwise specified. For wall or ceiling mounting, the end shields or bearing housing must first be turned through the corresponding angle and the connections rearranged as per diagram or instructions furnished by the manufacturer. Some machines with brushes may require special brush holders when mounted on the wall. It is preferable that adjustments for ceiling or side wall suspension be made before the machine is shipped and the manufacturer should be advised accordingly when the machine is ordered.

Whenever the end shields are removed, care must be exercised to see that the surfaces of the joints are perfectly clean before the end shields are replaced and the bolts tightened, otherwise the alignment may be so affected that the bearings will heat unduly. The air gap should also be checked to see that it is uniform all around after the end shields have been bolted into place.

III—Method of Drive

Bearings.—Before a machine is started the bearing housings should be inspected to see that there is no dirt or foreign matter in the reservoirs and that the oil rings are free. If the reservoir is not clean, it should be rinsed out with kerosene. The reservoirs should be filled to within one-sixteenth inch of overflowing with a petroleum oil before the motor is started.

Connections and Drives.—The connection of leads to machine terminals should not be of a permanent nature until the direction of rotation or polarity has been determined. When a controller or starter is required it should be connected in accordance with the diagram or instructions furnished with it.

All permanent connections should be made mechanically and electrically secure and the terminal wires must be securely soldered into the connectors supplied with the machines.

All wiring should be carefully installed in accordance with the National Electrical Code and any local requirements, and should be of ample capacity so that the voltage drop will not exceed 2 per cent at full load current.

Safety Regulations.—All belts, chains, gears, couplings and machines should be properly housed or suitably guarded in accordance with the National, State or Local Safety Regulations in effect.

Belt Drive.—The pulleys of the driving and driven machines must be accurately aligned and the belt tension so adjusted that the belt is

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just tight enough to carry the load without slipping. The smooth side of the belt should be next to the pulley. Wherever possible, the lower side of the belt should be the driving side, that is, the tight side of the belt should be at the bottom and the slack side on the top.

Horizontal belt drives are best and vertical belt drives should be avoided. The distance between pulley centers with open belting should never be less than 2½ times the diameter of the larger pulley. Pulleys should be placed as close as possible to a bearing. Double-ply belts should not be used on pulleys less than 9 inches in diameter. The use of endless belts is recommended. Where it is necessary to have short belt centers or vertical belts, a belt-tightener should be used. When a motor belt requires frequent adjusting, it is advisable to have the adjusting screw of the sliding base on the side of the motor nearest the belt. Excessive belt tension can be avoided by using belts of the proper width. The following statement will afford a rough check:

1-in. width will transmit with single leather belting 1 hp., and with double leather belting 1.4 hp. for each 1,000 feet per minute belt speed up to a maximum of 5,000 feet per minute.

The following limitations represent good practice in belting motors under normal conditions to relatively high speed drives:

The use of 1,800 or 1,700 r.p.m. belted motors should be limited to a maximum of 40 hp.

The use of 1,500 or 1,440 r.p.m. belted motors should be limited to a maximum of 50 hp.

The use of 1,200 or 1,150 r.p.m. belted motors should be limited to a maximum of 75 hp.

The use of 900 or 850 r.p.m. belted motors should be limited to a maximum of 125 hp.

Gear Connection. — Geared machines must be accurately aligned and rigidly fastened to a common base. An error of a few mils may produce serious vibrations and ultimately break the shaft or wreck the apparatus. When gears are properly meshed, it should be possible to pull a thin piece of paper from between the teeth without its tearing.

The following limitations represent good practice in gearing motors, based on the use of steel pinions:

The use of 1,800 or 1,700 r.p.m. geared motors should be limited to a maximum of 5 hp.

The use of 1,500 or 1,440 r.p.m. geared motors should be limited to a maximum of 10 hp.

The use of 1,200 or 1,150 r.p.m. geared motors should be limited to a maximum of 25 hp.

The use of 900 or 850 r.p.m. geared motors should be limited to a maximum of 50 hp.

The use of 750 or 720 r.p.m. geared motors should be limited to a maximum of 75 hp.

The use of outboard bearings should be specified for general purpose motors with geared drive in frame sizes of 75 hp., 850 to 900 r.p.m., and larger.

Direct Connection.—Direct connected machines must be mounted on and rigidly fastened to a common base and it is essential that the machines be accurately aligned. It is even essential that the two shafts be in line where so-called flexible couplings are used, otherwise trouble from end thrust may be encountered.

Couplings are usually so made that a straight edge can be placed against the outer diameter to determine whether the coupling faces are in line. This check on the alignment should be made on top, bottom and sides, and with rotating parts moved to different positions.

Chain Drive.—Machines must be accurately aligned for chain drive and so mounted that the chain may be tightened. Wherever possible, vertical chain drives should be avoided and the machines should be so mounted that the chain may be conveniently taken off and replaced without an undue loss of time.

IV—Operation Covering Initial Starting and Stopping.

The precautions which should be observed by the operator are given in the accompanying table.

Practical Points in Operation of Motors and Generators

That Will Prevent Injury Through Ignorance or Carelessness When Equipment Is First Started And Stopped and After It Is Placed in Service

1. *In General, Make Sure:*
(a) That all belts, nuts, screws, and oil drain plugs are tight.
(b) That the oil wells are filled with a good grade of mineral oil.
(c) That the commutator, slip rings and other parts are clean.
(d) That after all possible external load has been removed, the armature or rotor can be turned over by hand and runs freely.
(e) That all external wiring connections check with the manufacturer's diagrams.
(f) That the brushes move freely in the holders and make firm, even contact with the commutator or collector rings.
(g) That wherever possible both motors and generators are operated initially without load (except series motors, which should never be operated with less than 50 per cent full load), for a period of several hours.

2. *When Starting Motors, Make Sure:*
(a) That the line voltage (and frequency on A. C. motors) corresponds with the voltage on the nameplate.
(b) That the controller is in the "off" position.
(c) That the circuit breaker (where used) or the line switch is closed first.
(d) That the controller handle is then slowly but firmly moved on to each point of contact until it is in the running position (about 20 seconds should be consumed in this operation).
(e) That if a compensator is used, its switch lever is moved to the starting position and when the motor comes up to speed (in about 5 to 20 seconds) the lever is quickly thrown into the running position.

3. *When Starting Generators, Make Sure:*
(a) That all resistance in the field rheostat is placed in the field circuit.
(b) That all switches connecting the generator to any load are open.
(c) That the prime mover is slowly started and brought up to speed.
(d) That the resistance is gradually cut out of the field circuit until normal rated voltage is secured.
(e) That the load is then gradually applied.

4. *When Stopping Motors, Make Sure:*
(a) That the circuit breaker or starting compensator is tripped or the line switch opened.
(b) That the controller handle has returned to the "off" position by the time the motor has stopped.

5. *When Stopping Generators, Make Sure:*
(a) That the load is reduced by adjusting the field rheostat to increase the resistance in the generator field and that when the load is comparatively small, all the field resistance is inserted in series with the field windings.
(b) That the circuit breaker or line switch is opened.
(c) That the prime mover is shut down.
(d) That the field switch is opened on separately excited machines.

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Parallel Running of A. C. Generators.—A. C. generators which are to operate in parallel must be run at speeds which will give equal frequencies. The successful operation of generators connected to different prime movers is dependent in a great measure upon the governing of the prime movers and upon the relative flywheel effects of the different machines.

Synchronizing.—Before two alternators are synchronized for the first time, they should be tested for phase rotation. This can be accomplished by connecting each separately to an induction motor to see if the same rotation is obtained. Another method is to throw the machines together on very low voltage with ammeters in circuit. Wide fluctuation of current on the ammeters will indicate wrong phase relation. The phase rotation can be reversed by interchanging two leads of a three-phase machine or reversing the two leads of one phase of a two-phase machine.

The usual method of synchronizing is by the use of a synchroscope. A common method, however, is to connect a lamp or lamps of proper voltage in series with the low tension windings of two transformers, the high tension windings of which are connected, one across the line and the other across the incoming machine. If the secondaries are opposed, that is, connected as for ordinary multiple connection, the main switch of the incoming machine should be closed when the lamps are dark. If the secondary or the primary leads of one of the transformers be reversed, then the main switch of the incoming machine should be thrown in when the lamps are bright. It is preferable to connect for synchronizing when the lamps are dark. The main switch should not be closed until the fluctuations in the light of the lamps become slow, that is, about one in two or three seconds.

Stopping Generators in Parallel.—The prime mover should be throttled and the field current reduced until the ammeter and wattmeter indicate a very light load. The oil circuit breaker should then be tripped, the prime mover stopped and the field switch opened.

V—Care and Maintenance

Inspection.—A systematic inspection at least once a week is necessary to insure the best operation of motors and generators and the following points should be given special attention and consideration.

Cleanliness.—Both the interior and exterior of machines should be kept free from water, oil, dirt, or grease. For machines installed in very dirty places, troubles may be averted by periodically removing the rotor or armature and thoroughly cleaning the machine. A vacuum cleaner is highly recommended for cleaning assembled machines. The use of compressed air is not recommended on assembled A. C. motors. It is especially objectionable on machines installed in foundries, machine shops, or locations where there is much carbon dust, metallic chips, etc., as the compressed air may drive the dirt or metallic chips into the windings, and cause breakdowns. On direct-current machines the use of compressed air is not objectionable because all the parts are more or less accessible, especially the commutator and brushes.

Lubrication of Bearings.—The life of bearings is affected by the lubrication, belt tension and alignment of the driving and driven shafts. Excessive wear and heating of all bearings can be reduced to a minimum by adequate lubrication, proper belt tension and accurate alignment. When bearings are unduly worn, they should be replaced, and after the new bearings have been put in, the air gap should be tested to see that it is uniform all around.

Oil wells should be filled with petroleum oil (not vegetable or animal oil) through the oil fillers while the machine is at standstill up to one-sixteenth inch of the top of the oil filler. Experience has shown that animal or vegetable oils or greases, or admixtures of them with mineral or petroleum oil will dry and gum, and by gumming ducts and oil rings, prevent the free flow of oil to the bearings. Incorrect oil level may be experienced if the oil wells are filled while the motor is running. After a motor has operated for the first week, the oil should be drawn off and the bearings washed out with kerosene, to wash out all sediment before refilling the bearings with oil. The drainage plugs should be taken out and dipped in a mixture of red lead and shellac and then replaced and tightened securely to prevent leakage. The bearings should be refilled at regular intervals, the frequency depending upon local conditions, such as cleanliness, severity or continuity of service, etc. After changing the oil, the oil rings should be inspected to see that they are in proper position and turn freely.

Brush Tension.—The brushes should be inspected to see that they move freely in the holders and at the same time make firm, even contact with the commutator. The brush tension should be checked regularly to make sure that the proper tension (1¾ lbs. to 3 lbs. per sq. in.) is maintained by the spring.

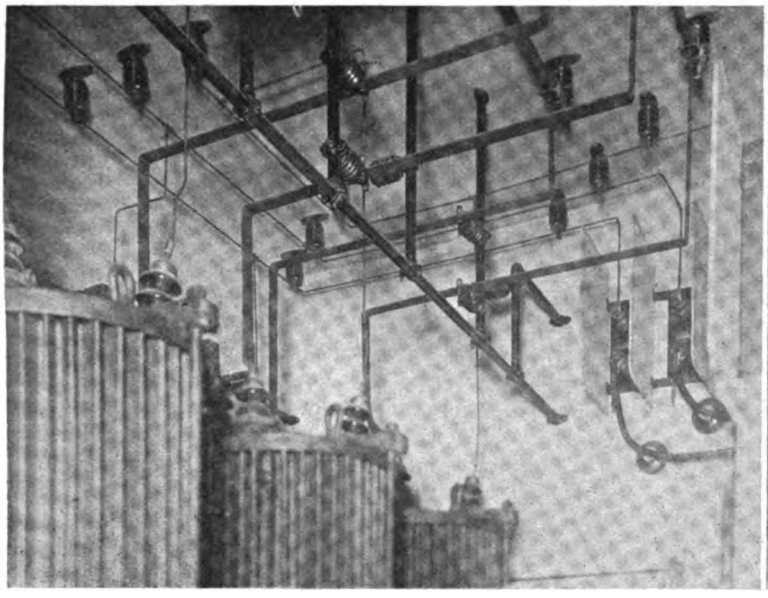
Fitting.—When replacing brushes they should be fitted by means of fine sandpaper folded around the commutator and the rotor revolved by hand in the desired direction until a proper fit is obtained. On some machines, the sandpaper can be held in place if it is cut to a width slightly narrower than the commutator, and the front end of the strip inserted into one of the narrow slots between commutator bars (where the mica has been undercut), and then folded back around the commutator by slowly revolving the armature by hand until the paper moves under a set of brushes.

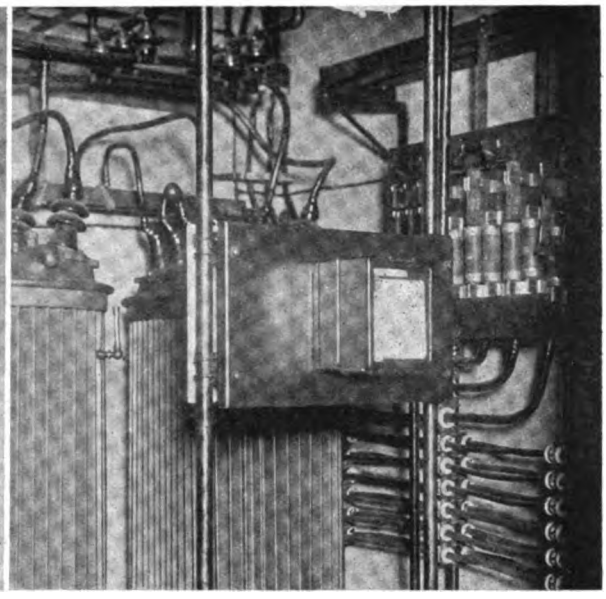
Position.—An operator should never shift the position of the brushes unless he knows positively that the brush position is incorrect or it is desired to change the direction of rotation or mounting of the machine. On machines with commutating poles, the position of the brushes is fixed on the neutral point at the factory and the position of the brushes on such machines should never be shifted except to make change as indicated in the previous sentence or for compounding or parallel operation of generators.

Brush Pigtails.—Care should be taken to see that the pigtails or flexible copper conductors are firmly fastened in place so that they will carry their full current from the brush to the brush holder. A slight extra length should be left in the pigtails because if they are too tight they might tend to pull the brush out of line and out of proper contact with the surface of the commutator.

Commutator.—Commutators should be always kept clean and well polished. Under normal operating conditions, a commutator will require only occasional cleaning with a piece of canvas or non-linting material. No vaseline or oil of any description should be used on a commutator. In case the commutator has become rough, this roughness may be removed by polishing the commutator with a piece of sandstone, which is formed to the same radius *(Continued on page 563)*

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The photograph at the left shows three 333-kva. transformers with bare copper buses for 15,000 volts on post-type insulators. The low-tension buses of rectangular copper are likewise supported on post-type insulators some of which are on the ceiling while others are fastened to a pipework frame. The photograph at the right shows how the low-tension feeders are carried by spool-type insulators which are clamped to pipes. The distribution switchboard is shown at the extreme right and the 450-kva. transformer bank is in the rear.

Details on the

Remodeling of An Industrial Substation

To Receive Purchased Energy at 13,200 Volts Together With Some Installation Features That Held the Cost Down.

By EUSTACE C. SOARES

Electrical Engineer, Orphuls & Hill, Inc., New York, N. Y.

IN THIS article layout and installation details are given for the remodeling of a 1,450-kva. substation at the plant of the Anheuser-Busch Ice & Cold Storage Company in New York City to receive energy from the New York Edison system at 13,200 volts and provide a safe installation at a reasonable cost.

The substation originally had three 150-kva. transformers operating at 7,800/440-220 volts. There have been added three 333-kva. transformers and the building was enlarged to house this additional equipment. These transformers are operating at 7,800/440-220 volts, but they may also be connected for 13,200 volts on the high-tension side. The high-tension equipment is designed for 15,000 volts. The entire job consisted in enlarging the building, installing the new 1,000-kva. bank of transformers with switches and buses, and making connections from this and the old bank to the new distribution switchboard, connecting the plant feeders to this board, and other minor alterations. A bill of materials covering this construction, but omitting the materials required for the building itself, is listed in the accompanying table. The cost of the material during the winter of 1921-22 was $7,319. Enlarging the building, blocking up an old door and cutting a new one cost approximately $1,675. The construction work was done by the plant operating department under the direction of the consulting engineer. If a contractor had done the work the charges would have probably been higher to allow a profit.

WHEN IT BECAME necessary to make changes in a step-down transformer substation at an industrial plant in New York City, to receive energy purchased from a central station system at 13,200 volts, some construction details of transformer house, buses and wiring layout were worked out that held the completed cost of the 1,450-kva. substation, including building changes, to $6.20 per kva. The bill of material and installation details given in this article show how this job was handled.

The center part of the substation building is reserved for the New York Edison Company's incoming 7,800-volt line switches, meters, etc. From this point high-voltage cables run towards both transformer banks which are located at the ends of the building. This is No. 0, 15,000-volt, single-conductor, varnished-cambric-covered cable and it is supported by 15,000-volt, pin-type insulators. This cable connects to three single-pole disconnect switches at each transformer. From these switches the new construction is of ⅜-in. bare round copper rod. As seen in the photograph on this page, the bare rod bus is carried over the transformers near the ceiling on 15,000-volt cement post insulating supports.

The low-tension bus is similarly mounted on the ceiling and consists of 3-in. x ½-in. copper bars. The photograph shows clearly the overhead bus construction which gives

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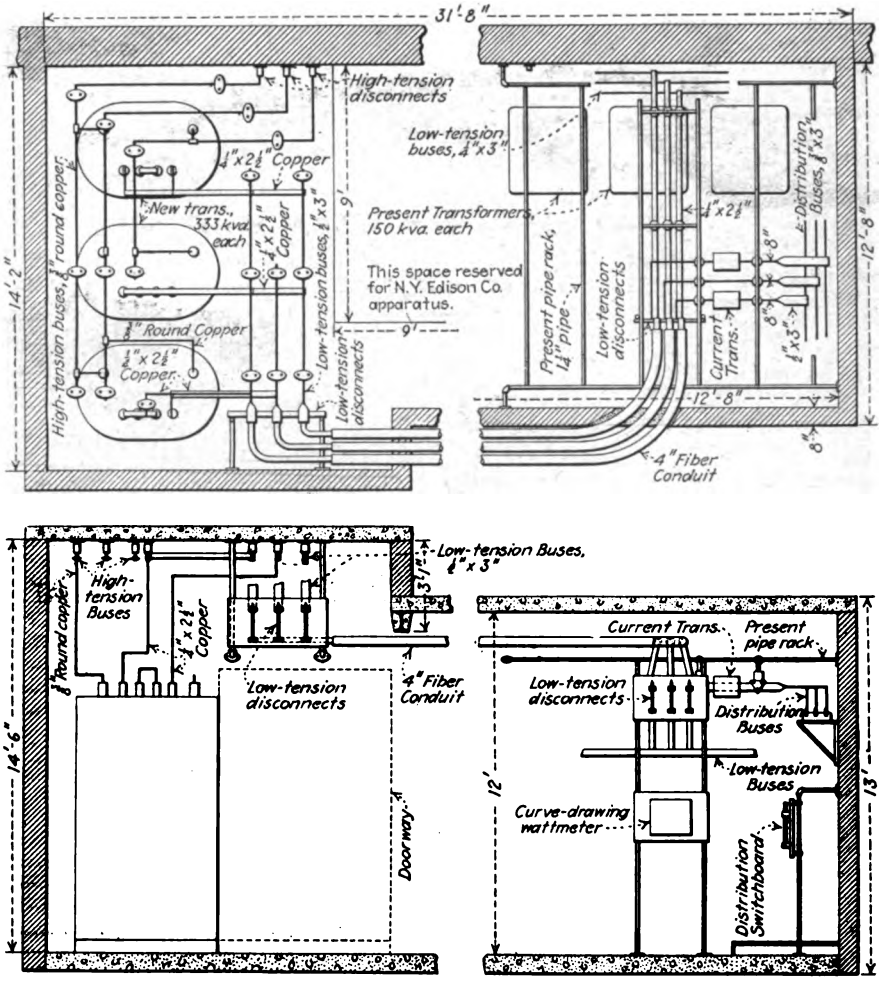


Fig. 2—Layout of buses and wiring for the 1,500-kva. substation shown in the photographs at the start of this article.

a very neat arrangement. Additional supports for some of the leads from the buses to the transformer terminals were mounted on a pipe framework, as may be seen.

Where an industrial substation is provided with a proper room of its own to which no one has access but the men whose duty it is to operate it, and especially where the buses can be mounted up near the ceiling, the bare bus type of construction is to be preferred. It makes a very neat job at a reasonable cost, and there is no question as regards safety. Men are always more careful around bare copper than where the wire is insulated. Of course, this statement regarding safety does not apply where the transformer bank is so small that the terminals can be readily reached from the floor. In such a case it is probably preferable to use insulated wire. It has been general practice to use insulated wire for the high-tension bus in industrial substations but this has been due mainly to convention rather than for any other reason.

Bill of Material for a 1,450-kva. Substation

THIS LIST of electrical materials is for a 1,450-kva. substation operating at 7,800/440-220 volts and designed for 13,200-volt operation in the future. All the high-tension equipment is rated at 15,000 volts. The station has two banks of transformers, one old 450-kva. bank and a new 1,000-kva. bank. All of the equipment* used is included in this list except the old transformers and their buses and leads.

3 Transformers, O.I.S.C. 333 kva. each, 13,200-7,800/440-220 volts.

6 Disconnecting switches, 100-amp. 15,000 volts.

1 Slate panel (2-in.) with three 1,500 amp. disconnecting switches for low-tension side of 1,000-kva. bank.

1 Slate panel (1½-in.) with three 600-amp. disconnecting switches for low tension side of 450-kva. bank, complete with pipe support and slate panel for meter.

1 Distribution switchboard complete with fuses and pipe support. (See text.)

24 Insulators, pin-type, 15,000 volt.

17 Cement post insulating supports, 15,000-volt, for ⅝-in. round bus.

12 Single-pipe-mounting clamp insulator supports; 6 with 1½-in. spools and 6 with 1-in. spools.

48 Double-pipe-mounting clamp insulator supports; 18 with 1⅛-in. spools and 30 with 1-in. spools.

Porcelain spools: 5 sets 1-in., 1 set 1½-in.

1 Curve-drawing wattmeter.

2 Current transformers, slip-over type, 1,200 to 5 amp.

100 ft. Cable, No. 0, 15,000-volt, single-conductor, varnished-cambric-covered.

50 ft. Ground wire, No. 2.

250 ft. Wire, rubber-covered, double-braid, No. 14.

Bare copper, round, 10 lengths, 10-ft. long, ⅝-in.

Rectangular hard-drawn copper: 8 pieces, 12-ft. long, 2½-in. x ¼-in.; 1 piece, 10 ft. long, 2½-in. x ¼-in.; 4 pieces, 12-ft. long, 3-in. x ½-in.; 2 pieces, 10-ft. long, 3-in. x ½-in.; 3 pieces, 8-ft. 10-in. long, 3-in. x ⅛-in.; 60 ft., 1½-in. x 1¼-in.; 10-ft., ⅝-in. x ⅛-in.

9 Fiber conduit, drive-joint, 5-ft. lengths, 4-in. diam.

3 Fiber conduit elbows, 90-deg., 36-in. radius.

20 ft. conduit, 1-in. and 70 ft. ½-in.

Conduit fittings: (3) brackets for supporting fiber conduit; (2) 1-in. E condulets; (1) 1-in. L.L. condulet; (1) 6-hole Porcelain cover for 1-in. condulet; (2) 3-hole covers; (5) ½-in. L.L. condulets; (5) ½-in. couplings; (6) junction boxes; (10) ½-in. bushings; (20) ½-in. locknuts; (3) base receptacles for attachment plugs.

150 ft. Pipe, 1¼-in.

Pipe fittings: 28 oval floor flanges; 14 clamp tees; (15) 90-deg. elbows; 1 side outlet elbow; 12 single U-bolt panel supports.

1 Exhaust fan, 18-in.

1 Wooden platform in front of distribution switchboard.

1 Rubber mat for platform.

1 Cut-out, 3-wire, 6-amp.

1 Snap switch, 20-amp.

3 Bracket lights with keyless sockets.

1 Switch hook, 6-ft.

Miscellaneous parts: Copper plated bolts, nuts and washers; cable lugs; screw connectors; bolts; nuts; lag screws; lead shields; bus-bar clamps, etc.

Miscellaneous materials: 12-lb., ¾-in. friction tape; 12-lb., ¾-in. rubber tape; 15-lb., ¾-in. varnished cambric tape; 1 gal. black insulating varnish; 6 balls twine; 35-lb. solder; 8-oz. soldering paste; 60-lb. kalsomine.

**The transformers were furnished by the Packard Electric Company; the high-tension equipment by the Electrical Engineers Equipment Company; the curve-drawing wattmeter by The Esterline-Angus Company.*

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Disconnecting switches are placed on the low-tension side of each set of transformers. From the disconnecting switches of the 1,000-kva. bank to the low-tension bus there is a run of about 20 ft. As room was scarce inside the transformer house, this run was made outside the wall in 4-in. fiber conduit. Four 500,000 circ. mil cables per leg were employed. The use of fiber conduit gave an opportunity to use old cable for this run and thereby save money. There was a considerable amount of old cable which had been removed from engine-driven generators when they were replaced by the new transformer bank. The insulation on this cable was in poor condition but when it was installed in the fiber conduit good insulation on the cable was not necessary. This circuit and the disconnecting switch of the old bank of transformers connect to a short bus running to the distribution bus. Current transformers for a curve-drawing wattmeter are placed on this small bus. The meter panel as shown in the photograph on page 545 is mounted on the frame which supports the low-tension disconnecting switches of the 450-kva. bank.

The distribution bus is mounted over the distribution switchboard. It is of 3-in. x ⅜-in. copper bars. Connection is made to the switches on the board by about 2-ft. runs of copper bars. For the two 800-amp. switches 1½-in. x ½-in. bars are used; for the two 400-amp. switches, 1½-in. x ¼-in. bars; for the one 60-amp. switch, ⅝-in. x ⅛-in. bars. Each switch is three-pole single-throw. From the fuses below these switches the feeders are of rubber-covered wire which is supported by clamp-type insulators attached to iron pipes.

The transformer room is located in a large covered areaway where trucks drive in for loading and unloading. The accompanying drawing shows the general dimensions of the building. It was necessary to remove one wall of the old transformer room when putting on the extension. To provide for the maximum of safety to the workmen, a full wooden partition was built up just behind the wall in the old room and left up until the entire new room was completed. When the wall of the old transformer house was removed an I-beam was strung across to support the roof of the present house and the northern wall of the new house. Proper precautions were taken to support the old roof before removing the wall. The walls of the new house are of brick and are 8 in. thick. An opening was cut for a double door 7 ft. 6 in. by 8 ft. with a steel girder installed to support the wall above the new door opening. A 6-ft. by 10-ft. self-closing fireproof door was also located in the eastern wall.

The floor of the new transformer house is of stone concrete (1:3:5 mixture) with a finishing coat of cement mortar, ½ in. thick. The new floor was made flush with the floor in the old transformer house and is so pitched as to drain into the floor drain of the old transformer house. For supporting the transformers three rectangular stone-concrete pads (1:2:4 mixture) 41 in. wide, 61 in. long and 12 in. high, were placed in the position shown in the drawing.

The roof of the new section consists of a stone-concrete slab (1:2:4 mixture) sufficiently strong to carry a live load of 60-lb. per sq. ft. The western edge of the roof projects 4 in. into a 16-in. wall so as to be properly supported on that side. The roof was waterproofed, given a slight pitch, and provided with a 4-in. drain. This was necessary as ammonia condensers were located on the roof of the areaway and the possibility of trouble due to water falling on the roof of the transformer house had to be guarded against. The old transformer room was ventilated by means of louvres in the door and in the opening placed in the outside wall. An exhaust fan was placed in the outer wall of the new section and provides additional and more dependable ventilation.

Operating Temperatures for Electric Motors

By O. C. SCHOENFELD

Motor Engineer,
Westinghouse Electric & Mfg. Co.,
East Pittsburgh, Pa.

EXPERIENCE with the operation of electric motors leads to the conclusion that the anticipated troubles from excessive motor temperatures are due largely to a lack of knowledge, on the part of the men in charge, of the safe temperature at which motors can operate; also the operators usually lack a reliable means of determining the temperatures. These men are familiar with the guarantees of 40 deg. C. or 50 deg. C. rise given by the motor manufacturers, but this actually does not convey to them a condition that can be determined by their customary method of measuring temperature by feeling the external surfaces of the motors. There is, then, a need for informing the operators of the safe temperature limit and impressing upon them the necessity of accurately determining the temperature rise.

A thermometer placed on either the coils or the core of the motor is the proper way to measure temperature. The customary "feel" method of determining temperature in which a motor is considered hot when the hand cannot be held on the motor frame for any appreciable length of time, is very unreliable and always leads to the conclusion that the motor is hot when it is well under the maximum safe temperature. The degree of heat that the human hand can withstand without causing pain varies greatly with different persons; for example, the hand of a blacksmith will not be nearly so sensitive to heat as that of a clerk. The maximum temperature which the hand of the average person can stand for a short time is from 55 deg. C. to 65 deg. C., which means that when using the "feel" method a motor will be considered hot when it is from 25 deg. to 35 deg. under the maximum allowable temperature. In other words, the maximum safe temperature limit now used by many operators is from 25 deg. to 35 deg. below the real limit. This was brought out recently at a certain mill where one of our service men had been called to test a motor which the mill engineer and electrician thought was running excessively hot and about to burn out. Thermometer readings taken on the motor showed an actual temperature of only 53 deg. The motor felt hot, but had a thermometer been used and had the men been familiar with the safe temperature limit, all of the unnecessary anxiety would have been relieved without outside assistance.

In many factories various kinds of electrical meters for checking the operation of the motors are found but rarely does this equipment include thermometers. Much can be done to relieve the anxiety over motors which feel hot by familiarizing maintenance men with the maximum safe operating temperature of 90 deg. C. and encouraging its measurement with thermometers.

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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, November, 1923

Don't Blame the Motor for Your Mistakes

A CORRESPONDENT recently told of a motor trouble which he had experienced that, when traced to its source, was found to be due to the use of a gear drive with too high motor speed. This is merely another bit of evidence in support of the fact that not all cases of motor trouble are primarily the fault of the motor itself. When trouble develops or abnormalities of operation are noticed with any piece of equipment, it will always pay to make a careful investigation to determine the real cause of the trouble. This is just as true of motor installations as it is of anything else.

The modern motor is as sturdy and reliable as human ingenuity and skill can make it. In its ruggedness and dependability it is second to few, if any, other pieces of equipment. Nevertheless, skill in the design and manufacture of motors can not entirely compensate for errors or carelessness in the selection, application or installation of motor drives.

For the purpose of giving motor users and operators the information which is necessary in order to avoid mistakes in these respects the Electric Power Club has recently issued a handbook of instructions covering the proper procedure in handling a motor from the time it is received in the plant until it is installed and put into service. Beginning on page 540 of this issue this handbook is reproduced in full and merits careful study on the part of anyone who has to install, operate or otherwise handle motor drives.

Equipment Will Not Compensate for Carelessness

WHEN THINGS go wrong many people grab the first patent cure-all that is handy and use it without stopping to consider what caused the trouble. In this they forget that the first step should be the removal of the cause, or the effect of the remedy will be only temporary. No man can continually eat too much and prevent stomach discomfort at the same time. Neither can he take a dose of medicine once a week, or every hour, when directions read "three times a day" and expect success.

Manufacturers of many kinds of equipment, particularly that designed to relieve the ills of operation—flexible couplings, clutches, silent chains, etc.—have been accused of making a patent medicine for the shop. Those who raise this cry the loudest point to a failure in their own shops. Investigations of these failures usually disclose that the new equipment was installed without removing the cause responsible for the former failure. For example, silent chains are installed without lining up the shaft; flexible couplings are put on and the alignment never checked up, or the couplings lubricated; belts too small for the load they are to carry, are used; self-aligning bearings are installed and the shafting never aligned.

Another common cause of failure which is similar to these, is to install equipment on a load much above the rating, to economize on first cost. The user then complains of the failure even though he took his medicine without reading or heeding the directions. Carelessness is often fatal when treating personal illness. Carelessness in following the rules prescribed by the manufacturer in the treatment of mechanical equipment may be just as serious. The metal or equipment that will take the place of common sense and carefulness has not yet been invented.

Talk Over Things That Are Not Wrong

CRITICISM and impatience on the part of the man who supervises others is sometimes a virtue and sometimes a fault. It all depends on the time and the place it is displayed. The man who is satisfied with everything and never offers suggestions for improvements is soon sized up as easy-going and the good-enough attitude gets into the thinking of his men. On the other hand the man who is never satisfied with anything and criticizes every job, however good it may be, is put down as a chronic grouch and a know-it-all, feared and disliked.

The first type is imposed upon and the second rarely ever develops initiative in his men, for they fear his criticism and follow instructions to the letter irrespective of the warnings of their better judgment. The superintendent or foreman who knows how to avoid a classification in these two extremes is the one who severely criticizes poor work and compliments good work with equal vigor and sincerity. A kind word and a helpful suggestion when things are going wrong in spite of the earnest endeavors of workmen, helps a lot, too.

But the best tonic of all for stimulating ambition and genuine interest in a hard-working gang, is a little talk by the boss on the things that have gone right and are going right because someone is using his head and applying his good judgment without being told every time. Just as nothing succeeds like success, initiative grows and thrives on results that bring a favorable comment from the boss. If you are not already doing it, call your men together once in a while and talk to them about the things that *have not gone wrong* and distribute the credit where it belongs. It pays.

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Cost of Pumping Water

RECENT tests on steam-driven and electrically-driven pumping outfits in a steel mill have produced data that show marked savings possible with centrifugal pumps. In this particular case 30,000,000 gal. of water were required per day. The operating cost for the electric outfit was found to be $71.40 per day and that of a turbine-driven outfit $86.40 per day, which shows a saving in favor of the electrically-driven centrifugal outfit of $5,475 during a year's operation of 365 days. This is about 14 per cent of the cost of the turbine-driven outfit and would pay for the less expensive electrically-driven outfit in less than three years.

The same tests showed that the operating costs of direct-acting steam pumps vary from 3½ to 15 times that of the motor-driven centrifugal unit. From the standpoint of maintenance and attendance costs there were also marked advantages for the electric unit. One factor often overlooked is that centrifugal pumps electrically driven do not require a licensed engineer and have no steam line losses when standing idle.

While it may not always be possible to use electrically-driven pumps exclusively, particularly where emergency outfits are necessary to guard against an interruption of water supply in case of failures of electric power or injury to motor, the cost of all steam pumping is now so uneconomical that replacement by some electric units is one way of reducing the cost of pumping water in a large industrial works that requires lots of it.

When Is Oil Not Simply Oil?

THERE was a time when oil was simply oil and bearing troubles were expected and provided for just as the replacement of grates in a boiler. But with the coming of the lubrication specialist times have changed and almost everything that causes bearing troubles is blamed on the lubricant used. Now we have oils and greases called by many funny names and to discuss their merits and uses requires a technical lingo that rivals the language of the young physician in diagnosing the measles.

To know when oil is oil and not grease something must be known about viscosity, low cohesion and high adhesion, specific gravity and flash point, the characteristics of high-grade parafin base crudes and chemically pure animal fats, straight mineral and compounded oils, shaft speeds and temperatures, bearing composition and pressures and a whole lot of other things that may or may not happen under certain prescribed conditions.

But if you are patient and have a good memory you can learn a lot from everyone you talk to about lubrication. It's a big problem in a large works where a wide variety of equipment is operated and a total lack of practical details of lubrication is certain to call for unexpected repairs and costly shutdowns. In making a study of your problems, however, it is important to determine the difference between competitive language aimed to sell oil and information that will reduce bearing troubles and repairs. When you have found something that works well it's a good plan to remember the saying of your first boss perhaps fifteen or twenty years ago, that oil is cheaper than machinery—use plenty of it!

Recognition for Electrical Men

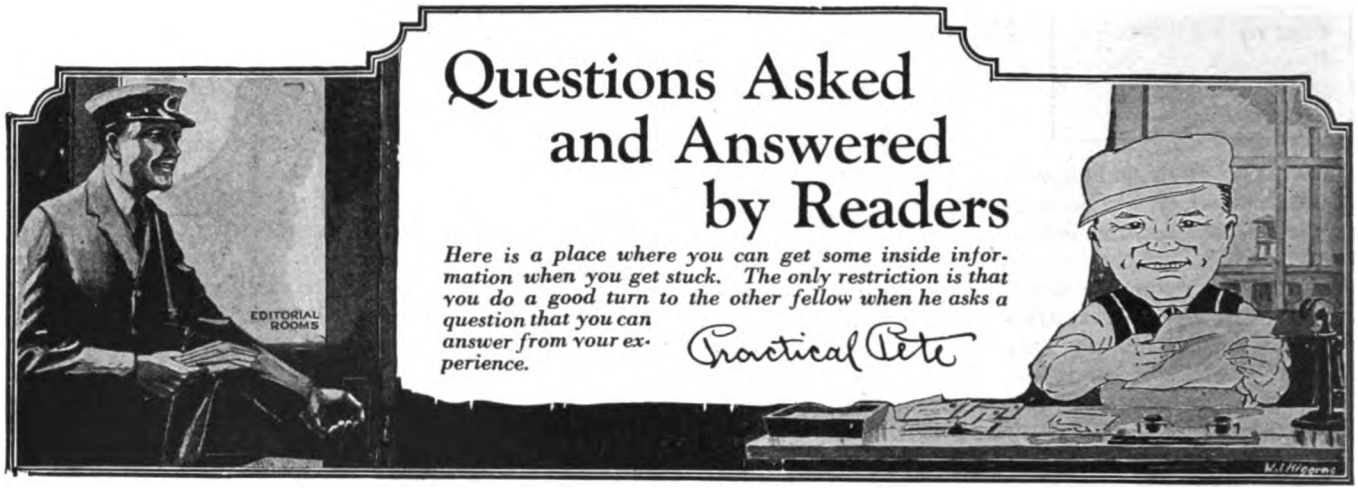
IN HIS paper "The Complete Electrification of the Foundry Industry" presented at the Buffalo (N. Y.) convention of the Association of Iron and Steel Electrical Engineers, Leonard W. Egan, engineer with the Ohio Steel Foundry Company of Lima, Ohio, pointed out that in foundries where power-driven equipment such as molding, sand-cutting and conveying machines and other devices has been introduced, the molder is allowed to apply his knowledge and skill to the best advantage and has increased his output from eight to ten times. In this connection he made a strong plea for a wider recognition of the results electrical men can secure in foundry work. He said:

> The advancement towards the complete electrification in foundries that now exists in the steel mills will not receive an impetus corresponding to that of the steel mill until foundry managements recognize the necessity of giving a higher standing to the electrical man. They must give him higher authority, allow a broader scope in his efforts and more consideration for his opinions and recommendations in the development of the industry. On the other hand, they should demand of him a broader knowledge of industrial-electrical applications and maintenance management in general. He must assume a more definite and stronger position in the application and the development of the equipment. He cannot longer be considered as a "trouble-shooter" and a "wire-fixer." He is a most vital factor in the production of service by each and by all units of the equipment. As the equipment is intended exclusively to produce and furnish service continuously and without interruption, without breakdowns if possible, and all of it at a minimum of maintenance cost, the degree of service that the equipment produces under operating conditions is intimately intermingled with his routine duties.

We agree most emphatically with Mr. Egan. But the ideas and responsibilities of electrical men in industrial work from a production standpoint are for the most part new. The extensive use of electrical service even in our large plants is a product of our present generation of workers, most of whom are still young. And those who have established for themselves jobs that carry recognition have had to fight their way to such recognition. It will not always be so. For management, even when most conservative, places responsibility on those who show results and on this basis electrical men in industrial work have a much brighter future than they may now realize. But nothing will be handed to them on a silver platter—it's results that count and of these there are plenty that are gradually but forcefully making a dent in the consciousness of industrial executives.

It is one of the functions of INDUSTRIAL ENGINEER to find the electrical men who are doing things and to interpret the results they are securing from a production standpoint in terms of profits in dollars and cents that the management can pass on to their stockholders as dividends. If you are one of these men remember the advice in the Good Book about hiding your light under a bushel. INDUSTRIAL ENGINEER provides the means for making a permanent record of what you have done along new lines and welcomes an opportunity to assist you in compiling the details.

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Who Can Answer These?

Tire Heater for Wheels of Mining Locomotives—I should like to know where I can obtain a device for heating the tires for removal from the wheels of mining locomotives. The wheels are about 14 in. in diameter. I should prefer some device that, if possible, will not require the removal of wheels from under the locomotives in order to take off the tires and can use kerosene or gasoline as a fuel. If any reader of INDUSTRIAL ENGINEER has made an outfit which will do this work I shall appreciate it if he will give me full details.
Kildav, Ky. C. F. K.

* * * *

Trouble with Balance Coils on Lighting Circuit—I recently had trouble with a lighting circuit which was to be supplied by a 440-volt, 60-cycle generator. We wanted to get 110 volts, but the only apparatus available to make this change was two Westinghouse balance coils, built for reducing 220 volts to 110 volts. Numerous connections were tried, such as hooking up the two coils in series across one phase of the 440-volt lines, but the balance coils just would not balance the load. One circuit would receive about 150 volts, while the other would show only 85 volts.

Can anyone who has had wider experience than I in this line suggest a way to make these coils work together? Or can you tell me just why they will not work?
Smackover, Ark. W. N. T.

* * * *

Inexpensive Rectifier to Supply Direct Current from A. C. Circuit—I wish to obtain 110 volts direct current and as only 110 volts alternating current is available I should like to get complete details of an inexpensive electrolytic or other type of rectifier whereby I can step up the 110-volt alternating current to compensate for losses in rectifying and obtain 110 volts direct current. I wish to operate small fans and motors with the direct current. I shall appreciate it if someone can tell me how to make a suitable outfit.
Portland, Ore. V. G. W.

* * * *

Changing Small D. C. Motor to Operate on Alternating Current—I shall appreciate it very much if someone can tell me how I can rewind a small, 22-volt, direct-current, Hamilton-Beach vibrator motor to operate on 110 volts alternating current. The armature has 21 turns of No. 26 enameled wire and two coils per slot. The span is 1 to 6. The pitch of the leads is straight out. The two field coils are wound with 116 turns of No. 21 wire and the motor is connected in series.
Minneapolis, Minn. H. E. S.

* * * *

Electro-Magnet for Use on Alternating Current—Will someone please give us the information needed to make an electro-magnet, for operation on 110-volt, 60-cycle alternating current, which will be suitable for use in taking steel particles from the eyes. If possible, we would like to know of some method of controlling the strength of this magnet which can draw up to 60 amp.
Chicago Heights, Ill. J. E. G.

* * * *

Trouble with Generator—Will some reader please answer the following questions? (1) We have two generators and when I synchronize and cut in No. 2 generator in the morning before the load comes on, the lights around the board grow quite dim, although the voltage holds up well, around 2,400. When the load comes on the lights become bright. When I run one unit at night and a pump load of about 32 amp. is thrown on, the voltage drops to 2,150 but the lights are very bright. The lights grew so dim this morning that I thought I was losing the load although the voltmeter read 2,400 and the board showed only a small load. Does the power factor have anything to do with this? Can I figure the power factor from our board? We have one voltmeter reading 2,400 volts and two ammeters showing about 75 amp., on one generator and 78 amp. on the other. (2) When both generators are running together and everything seems normal, we often hear a sort of groan, about the same sound as a short circuit on No. 2 generator. Once I was standing on the base of the generator when it gave this groan and I could feel the sound or vibration. The generator does this frequently when running with the other unit but no indication of anything wrong shows on the board. Could it be that it slows down while in step and the load on the generator changes without showing on the board?
Canmore, Alta., Can. V. H. L.

Answers Received To Questions Asked

In the October issue of INDUSTRIAL ENGINEER we noticed several answers to question asked by J. U. regarding the best way to remove insulation from enameled wire. Having read all of the answers we thought that a description of the method which we use might be of interest to your readers.

In our rewinding work we use enamel-and-cotton-covered magnet wire exclusively, and of course it is necessary to remove the insulation from all of the coil ends so that they can be easily soldered. We do this by holding the wire in the flame of a blow torch until it becomes red. This will burn off all of the insulation, and while the wire is still red hot we immerse it in wood alcohol. The wire comes out of the alcohol perfectly clean. In the case of small wires it is necessary to be very careful, otherwise the wire will melt. With wire of No. 18 gage or larger no trouble will be experienced. We have tried various ways of removing enamel insulation and find this to be the most satisfactory.

KOONTZ BROS. ELECTRIC CO.
South Bend, Ind.

* * * *

Operating Two-Phase Induction Motor on Three-Phase Circuit—I should like to know if a two-phase induction type or squirrel cage motor can be run on a three-phase circuit, keeping the same speed and pulling the same load. I should like very much to have someone give me a diagram of such a hook-up and state if the two finishing ends of both phases or the start of one phase and the finish of another are hooked together. On what principles will the motor operate?
Chicago, Ill. J. H. B.

In answer to J. H. B. in the October issue of INDUSTRIAL ENGINEER who wishes information on running

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a two-phase motor on a three-phase line:

The connection which he mentions is only a change from two phase, four wire to two phase, three wire.

I would refer him to page 6 of INDUSTRIAL ENGINEER for February, 1923, where the General Electric Co. advertises the type M. T. Q. auto transformer for changing three phase circuits to two phase, or *vice versa* to meet just such a condition as J. H. B. mentions.

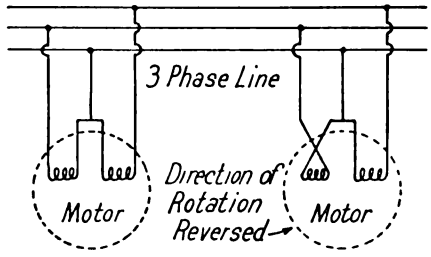
I think the only other practical way would be to open up the motor and reconnect the coils for three phase. This incident leads me to mention that, personally, I get almost as much education from the INDUSTRIAL ENGINEER'S ads as from the text, and that's saying something. ELLIOTT M. GASKILL.

Chief Electrician,
Empire Steel & Iron Co.,
Wharton, N. J.

* * * *

To the question asked by J. H. B. in the October issue of INDUSTRIAL ENGINEER, I would say that it is not very practicable to run a two-phase motor on a three-phase circuit, for the reason that the phases are of a different displacement on a two-phase circuit than on a three-phase circuit. In the former they are displaced 90 deg. while in the latter they are displaced 120 deg. In testing induction motors I have quite often run two-phase motors on a three-phase line in order to check them for end play and mechanical balance when our two-phase lines were in use. A motor can easily be run up to speed in that way for such checking, but it will take a larger current and it cannot pull the load that it would on a current of the proper displacement. If I wanted to use a two-phase motor on a three-phase line I would arrange to start the motor on the three-phase line and as soon as it was up to speed, open up one phase and run it single-phase, at which it should carry 60 to 70 per cent of rated load without trouble.

As to the last question, I will say that the principle of operation is the same as normal except that on account of the difference in the phase displacement the stator and rotor poles do not coincide with each other as they travel around. That is, at the same frequency the speed of the motor will be the same but the magnetic flux will be distorted by the difference between 90 and 120 deg. The motor has a good starting torque but when running it acts one instant as a motor and the next instant as a generator. Under actual test a 3-hp., 220-volt, 1,140 r. p. m., two-phase, 60-cycle, squirrel-cage motor took just about full load current when running idle on a three-phase, 220-volt line, the current being 5.5 amp. in one phase and 7 amp. in the other phase. The hook-up is very simple, as is shown in the accompanying sketch.



Connections for operating a two-phase motor on a three-phase circuit.

PHILIP G. BERNHOLZ.

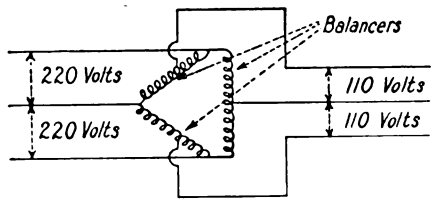
East Orange, N. J.

* * * *

How to Secure 110- and 220- Volt Service from 220-Volt Generator—We have a 7.5 kva., 3-phase, 220-volt, 60-cycle self-excited a. c. generator that we desire to use at night for lighting the boiler and turbine room and some residences across the street. I would like to have some reader tell me what transformer connections I can use to obtain 110 or 220 volts on the secondary side, so as to balance the load on all three phases. Would it be possible to use a balance coil with a three-wire secondary? If so, I would like to see a diagram of connections that will be most satisfactory.

Henderson, Ky. J. M.

When J. M. asked in a recent issue for a transformer or balancer connection to give him 110 and 220 volts on the secondary side and said that he wished to keep the load down, I assumed that there was to be a full load on the machine. If this is true the best balancer connection would be to put balancers across all phases, as shown in the illustration, and supply the load from the three centers of the balancers. If the greater part of the load is across the street, it would be better to put the transformers over there and run one neutral or 110-volt line back to the boiler room. This circuit has the advantage that the transformers do not have to be of the same voltage to get the balanced 110 volts as the only requirement is that the wire be large enough on the balancer to carry the current. For instance, a 440-volt winding with the neutral brought out can be used if the wire on the core is large enough. This may enable you to use any transformer that may be handy. If there happens to be a spare balancer handy there would be no need of running the neutral back to the boiler house as it can be gotten from this fourth balancer which would be located in the boiler house.



The 110-volt lines are taken from the centers of the three balancers placed across the phases.

If I am wrong in the assumption that the machine is fully loaded, it would probably be advisable for you to cut the field of the generator down so that the output of the machine is around 115 volts. This would eliminate the expense of installing transformers, but it would also cut the capacity of the generator to about half of its normal rating.

Buffalo, N. Y. R. M. BEECHER.

* * * *

Derivation of Chord Factor—(1) In his answer on rewinding a motor for four speeds, A. C. Roe says, on page 212 of the April issue: "Assuming a 1 and 12 pitch the chord factor is .99144. . . . . Then the voltage per turn for full pitch will be (127x1.009) divided by 104 . . . . . For a 1 and 10 pitch the chord factor is .92388, and full pitch voltage per turn equals (127 x 1.076) divided by 104 . . . ." I should like to know how the values 1.009 and 1.076 are derived, as the chord factor differs from the values given.

(2) In A. M. Dudley's book, "Connecting Induction Motors," there is given on page 187 the output coefficient values for 4, 8, 10, 12, 16, 20 and 24 poles. What values should I use for 2, 6, 10, 14, 18 and 20 poles?

Santa Barbara, F. R. G.
Chihuahua, Mex.

In reply to the question by F. R. G., the value 1.009 is derived by subtracting the chord factor from one. This method of calculation introduces a slight error but is quicker than finding full pitch voltage, which is volts at any pitch divided by the chord factor for that particular pitch. In the case of the 1 and 10 pitch, full pitch voltage equals $127 \div 0.92388 = 137.4$. Then $127 \times 1.076 = 136.65$, or a difference of $137.4 - 136.65 = 0.75$ volts which, for practical purposes, is negligible. The same reasoning applies also in the case of the 1 and 12 pitch.

For the coefficient values for two poles, use twice the four-pole value found from the table in A. M. Dudley's book "Connecting Induction Motors." For six poles, use twice

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the 12-pole value. For ten poles, use twice the 20-pole value. In other words, figure the rating out as for a 6-pole motor; then multiply the results by two, which is close enough. For fourteen poles, figure out as for twelve poles and multiply the result by 0.85. For eighteen poles figure as for twelve poles and multiply by 0.66. In each case check the iron below the slots and the teeth as explained by Mr. Dudley. A. C. ROE.

Detroit, Mich.

* * * *

Requirements for Grounding Conduit—I would like to get some information on practice in grounding conduit. Has the section of the National Electrical Code, 1920 edition, paragraph F on page 27 of section 12 on wires covering class B outside work been changed? I refer to the ruling regarding short lengths of conduit for entrance wires. Formerly where only a few inches of conduit were used to make an entrance it was not required to ground this conduit, providing no conduit was used inside the building and the voltage was less than 150 volts. We are now required to ground all such conduit to a 1-in. gas pipe, which seems unreasonable and adds at least four or five dollars to the job. I would like to hear from other readers who have run into requirements of this kind.
Good Hope, Ill. V. W. M.

In answer to V. W. M's question in a late issue, according to the National Electrical Code, Rule 12f, paragraph 3, conduit containing no conductor of a circuit exceeding 150 volts to ground, may be left ungrounded if insulated from the ground and from the metal conduit, armored cable or metal raceways within the building and from all metal work on or in the building. It is not necessary, although desirable, to ground entrance conduits. This is in effect the meaning of the rule. However, various cities have made it compulsory that entrance conduits be grounded. This is to minimize life hazards. Any entrance conduit may accidentally become charged to a high potential due to the circuit it contains becoming crossed with high-tension wires out on a pole. Any person touching such a charged conduit may, if the conduit is ungrounded, be electrocuted. An unnecessarily large number of accidents due to this condition has been reported. If the conduit is grounded the fatality will not occur and it seems to me that any expense that can be charged to an item which increases safety is well worth adding to the cost of a job. In any event it would be only a small part of the total cost. MARTIN T. LANE.

Denver, Colo.

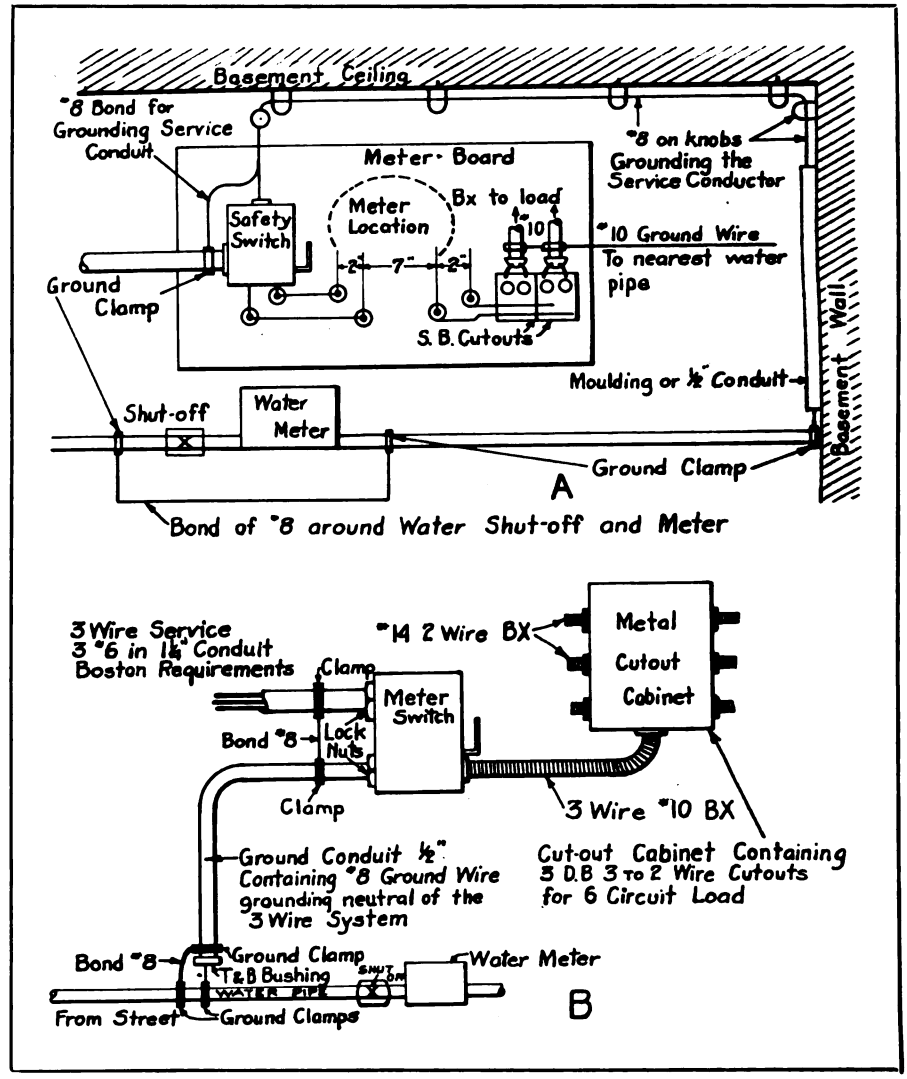
In a recent issue of INDUSTRIAL ENGINEER V. W. M. asked for experiences in grounding entrance conduit. In Boston, Mass., the inspectors require one service wire to be grounded to a water pipe; a gas pipe must not be used unless it is the only one available. The ground wire must be no smaller than No. 8 and need not be larger than No. 4 in any case, or one-fifth the carrying capacity of the wires inside the conduit. This ground wire, if it is a short run, must be run in conduit to the grounding connection on the water pipe. The ground clamp is attached to the water pipe on the *street side* of the water meter or shut-off. The conduit containing the circuit ground wire is then bonded to the water pipe. This makes two ground wires, in effect, with the conduit used as a ground conductor.

In Cambridge, Mass., two separate ground wires are required, one for service entrance conductor and one for the service entrance conduit. In both cities the ground must be on the street side of meter or shut-off.

In other cities and towns one ground wire is run just as any wire is installed, protected by conduit or molding where it comes down on the wall. One end of this ground wire will be attached with a ground clamp to water pipe or gas pipe on the street side of meters and the other end is connected to one service wire. Then a short bond is made from the service conduit to the ground wire, which thus serves as a ground for both service conductor and service conduit, as in *A* of the illustration.

Where conduit is used containing the ground wire, it is run from the safety entrance switch or meter switch, both of which are in iron boxes having conduits attached in the usual way with lock nuts and bushings. But where the conduit containing the ground wire is also used as a ground conductor, by bonding to a water pipe, a jumper is

A shows a typical suburban service with open meter loop, eastern Massachusetts. B shows a typical, totally-inclosed, overhead service entrance, eastern Massachusetts.



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often put on around the safety or meter switch from the service conduit to the conduit containing the ground wire, as in *A*.

In any case the BX used in the house circuit is bonded together at the meter board with No. 10 wire, and one or more lines of BX grounded to the nearest water pipe, usually in the basement.

In underground service no service grounds are required, but the house lines of BX must be bonded and grounded as usual. All cutouts in Boston must be in a metal box. The accompanying illustration shows typical examples of requirements in Boston and the suburbs. The ideal service entrance is shown in *B*.

Boston, Mass. EDWARD A. GIBBS.

* * * *

Reducing the Speed of A. C. Motor—We have a 20-hp., 440-volt, 3-phase, 60-cycle, 1160 r p. m. motor having 36 coils. Each coil has ten turns of two No. 11 wires. The coils lay in slots 1 and 11 and are connected in series-star. We want to change this motor to operate at 860 r. p. m., 440 volts, 3-phase, 60-cycles, and still develop 20 hp. with seventy-two coils. The stator is 13 in. in diameter with seventy-two semi-closed slots ⅝ in. wide by 1⅛ in. deep. The core width is 6 in. We have already wound this motor with seventy-two coils made of five turns of two No. 11 wires. The coils were placed in slots 1 and 8 and the group connected in series-star. On testing the motor we found that it ran 900 r. p. m. but took 44 amp. at 480 volts running idle, although it did not heat up much. Will some reader please tell us what size wire and how many turns per coil we should use?

Mansfield, Ohio. C. E. P.

In reply to C. E. P.'s question as given above in INDUSTRIAL ENGINEER with reference to rewinding a 20-hp. motor for lower speed, I would suggest that he always keep in mind the fact that in lowering the speed of a motor the counter e m f is lowered and consequently a larger current is drawn. To keep the line voltage back and decrease the current, a higher counter e m f. is needed, therefore, a greater number of turns of wire, for a lower speed.

In rewinding this motor put in thirteen turns of two No. 12 wires. Span 1 and 8 and connect series-star for eight poles, which will give you 900 r.p.m. at 60 cycles. The motor will no doubt develop slightly less horsepower, but it is the best you can do when lowering the speed of a motor, as it takes more iron and, therefore, a larger motor for a given horsepower at low speed than at high speed. H. A. NEILSEN.

Dynamo Electric Works,
Los Angeles, Calif.

Answering C. E. P.'s question in a recent issue, I offer the following:

If C. E. P. is able to get twelve turns of No. 11 wire in each slot and winds with seventy-two coils, throw 1 and 8, and connects them in series-delta, he will have a very satisfactory motor. However, the horsepower will be 17.25 instead of 20. If he is unable to get twelve turns of No. 11 wire per coil and must use No. 12 wire, he will have a 14-hp. motor. I believe that he can get twelve turns of No. 11 with the size slot he has. Practically, it is not possible to reduce the speed of an induction motor and keep the horsepower the same.

While I have no connection with the selling of books, I am quite sure that C. E. P. would find Dudley's "Connecting Induction Motors," published by the McGraw-Hill Book Company, to be a very interesting, practical and readable book on the subject of induction motor windings.

J. W. MURRY.

Ohio Valley Electrical Repair Works,
Moundsville, W. Va.

* * * *

Changing Winding of Induction Motor—What changes should be made in rewinding a three-phase, four-pole, 220-volt, 20-hp. induction motor for operating on a two-phase, 440-volt circuit? The original stator has 48 slots with 48 coils of 14 double turns of No. 14 wire connected two-circuit delta with a throw of 1 and 10. What would be the result if only the throw of the coils is changed to 1 and 12?

Fairfield, Me. M. D. B.

The motor in question will have to be rewound as follows: Since it is connected two-parallel delta for 220 volts, the series-delta voltage would be 440. There being 48 coils and slots, there will be 48 divided by (4×3) equals 4 coils per group for the three-phase winding and 48 divided by (4×2) equals 6 coils per group for the two-phase winding.

With a coil pitch of 1 and 10, the chord factor either two-phase or three-phase equals 0.92388. If the coil pitch is kept the same the chord factor will not be used in the calculations. The three-phase distribution factor for four slots per pole per phase equals 0.958, and the two-phase distribution factor for six slots per pole per phase equals 0.890 approximately.

Then with the same coil pitch and turns per coil, the two-phase line voltage should be 440×3÷2×0.890÷0.958 equals 613.14 volts, which is 39.3 per cent higher than the required 440 two-phase voltage. This means that the total turns per phase will have to be reduced. The required two-phase turns per coil equals 14×440÷613 or 10 turns.

The size of wire will have to be increased. The current per coil was equal to (line current divided by 1.73) divided by 2, for a two-parallel delta connection. The full-load line current for a 20-hp., 440-volt, three-phase motor is approximately 27 amp. Then the amperes per coil equals 27÷1.73 equals 15.6 amp. There were two No. 14 wires for the three-phase winding. These have a cross-sectional area of (2×4107) equals 8,214 circ. mils. Then 8,214 divided by 15.6 equals 526 circ. mils per ampere.

The full-load current for a 20-hp., two-phase, 440-volt motor is approximately 24. Then allowing the same current density, the two-phase wire size equals 526×24 or 12,624 circ. mils. Using two wires in hand to make a flexible coil the size of wire equals 12,624÷2 equals 6,312 circ. mils or two No. 12 double-cotton-covered. Using three wires in hand, 12,624÷3 equals 4,106 circ. mils or No. 14 wire.

The old winding had fourteen turns of two No. 14 double-cotton-covered, 56 wires per slot. The new winding would have 10×3×2 equals 60 wires per slot or four more wires than the old. However, by using single - cotton - and - enamel - covered wire the coil will wind.

The two-phase winding data would be 48 coils each having ten turns of three No. 14 single - cotton - and - enamel wire, pitch 1 and 10, series connected, six coils per group, 20 hp., four poles, 440 volts, two phases.

Satisfactory results would not be obtained by merely changing the pitch to 1 and 12 and reconnecting. To reconnect the winding into two-parallel for two phases and change the coil pitch to 1 and 12, would require a line voltage of 306.5×0.99144 ÷0.92388 equals 328.88 volts, 0.99144 being the chord factor of the 1 and 12 pitch. If the motor were put on a 440-volt line it would be operating on 34 per cent overvoltage. Also as there would be six coils per group in place of four, the phase insulation on the beginning and ending of each pole phase would be out of place which would weaken the winding.

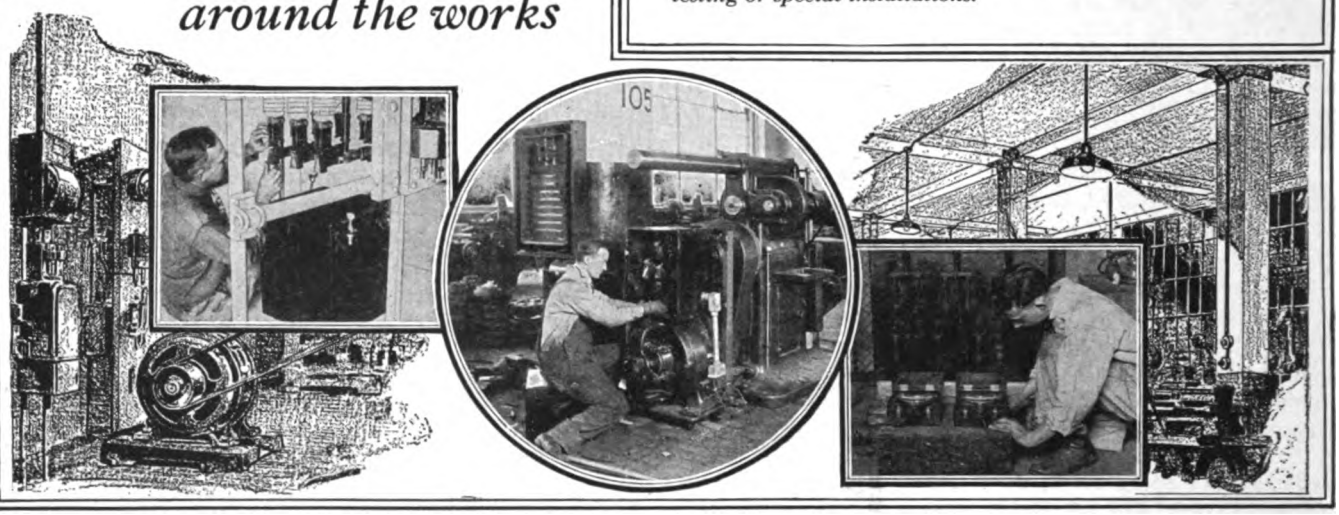
Taking all points into consideration, it would be good policy to rewind for 440 volts, two-phase.

Detroit, Mich. A. C. ROE.

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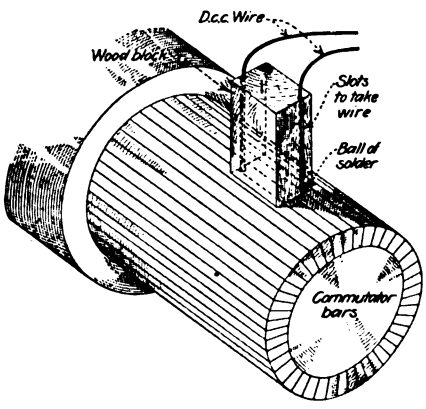
SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



How to Find Proper Position of Brushes on Commutator

A METHOD of finding the exact point for the brushes to rest on the commutator, applicable to both motors and generators, is shown in the accompanying sketch. In a direct-current machine there is a reversal of current in the armature coils as they pass under the brushes. This reversal is due to the fact that the current in the coil approaching the brush is flowing in one direction and after the coil has passed the brush the current flows in the opposite direction. Just at the instant of passing the brush the coil is short circuited. When the coil is short circuited a current is induced in it which cannot flow out anywhere and that is why the brushes must be placed so that this induced current will be of the smallest value possible; otherwise when the coil comes from under the brush there will be a spark due to the voltage forcing this induced current into the coil adjoining, the spark occurring at the brush just as the closed circuit is opened. When a motor or generator is loaded heavily an additional strain is placed on the machine if the brushes are not set properly.



A wooden brush with leads is used to locate proper brush position.

The only method in popular use for finding the proper point of brush position is to shift the brushes by moving the rocker arm first one way and then the other until sparking occurs, then bringing it back and allowing it to rest at the point in the center of these two places where sparking occurred. There are many times, however, when it will be found that there are as many as ten or twelve bars over which no sparking occurs, particularly if the machine is not heavily loaded. The center of this point is, of course, where the brushes should rest, but while the machine is running it is difficult to place them exactly in the correct position. Therefore the following method should be used:

Take one of the brushes out of the holder and make a block of soft wood just the size and shape of the brush. Have it fit the holder snugly. Cut a hack saw slot about ⅛ in. deep on each side of the block, spacing them so they come on bars next to one another. Take two long pieces of double-cotton-covered wire that will fit tightly in the hack saw slots. Push the wires in the slots so that they will not touch the sides of the holder and let them extend about 1-16 in below the bottom of the block. Bend these two ends toward one another and put a small drop of solder on each. Connect a voltmeter, or preferably milli-volt meter with an adjustable shunt, to the two leads.

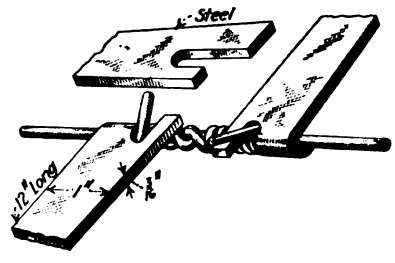
By moving the rocker arm first one way and then the other a reading on the meter will be shown in both directions. The absolute neutral point is where the deflection is slightest, because at this point there is the smallest amount of induced current in the short-circuited coil when under the brush.

Darby, Pa. GEORGE WM. HANLON.

How to Make a Jointing Tool For Heavy Wire

CONSIDERABLE effort is required to make joints with wire, and especially iron wire. Ordinary pliers will not handle the heavier wire and when large pliers are used the corrugations on them tend to cut into the joint and weaken it. The wire benders shown in the accompanying sketch are effective and simple enough to warrant adoption for the numerous instances when it is required to join sections of such wire.

Two of these tools are used and they are exactly alike. They will



Heavy wire is easily spliced with these tools.

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make a solid and workmanlike splice in any size wire. Each tool is made from a foot length of flat steel, 1 in. wide and 3/16-in. thick. The end is bent to form a lip and one side is cut out as a bender for the wire. The illustration shows the method of using these tools. G. A. LUERS.

Washington, D. C.

Third-Rail Construction for Electric Transportation in Steel Plant Yards

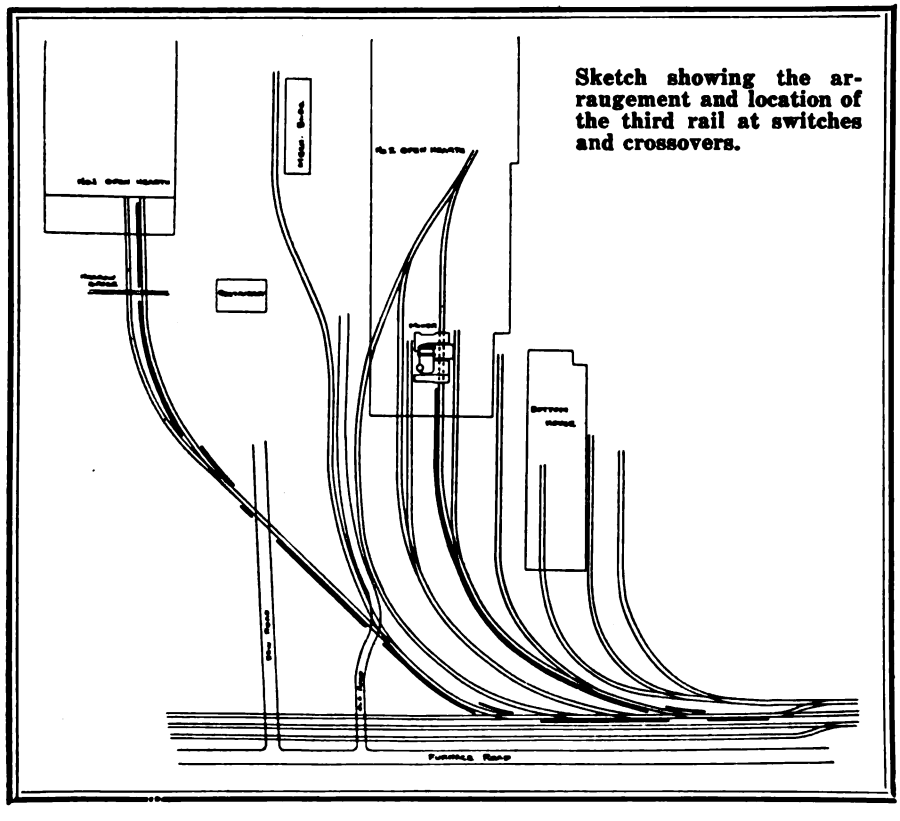
IN DISCUSSING the electrification of the yard of the steel plant at the recent meeting of the Association of Iron & Steel Electrical Engineers it was pointed out that the third rail lends itself more readily to steel plant yard electrification than an overhead trolley because it does not interfere with the work of locomotive cranes and it is better able to handle heavy operation at low voltage. For yard work where switchmen and plant employes may not be denied free and safe passage over all portions of the yard, the bottom contact system of third rail is preferable to the top contact system.

[The following is an abstract of the paper which was presented on this subject.—EDITORS.]

The third rail should be set as low and close to the track as possible and be covered with impregnated wood or other insulator, so that its bottom and about ¾ in. of its lower vertical surfaces are disclosed. Placing it low makes it easy to step across and with the insulated cover, it can be stepped on without danger. Locating it as close to the track as clearances of the rolling equipment will permit, makes it easier for the contact equipment to cross switches and crossings and enter buildings.

There are two methods of crossing switches, one by using a side approach fitting on the rail to guide the shoe into the contact position and the other to use an idler car to carry contact shoes, thus practically making the locomotive long enough to span any road or switch crossing. Since many of the operations about the steel plant require the use of a safety car, this is no burden and in any event if compared to the steam unit is more economical to haul and maintain than the tender. It is questionable if the idler car would be necessary with the two-unit locomotive where contact shoes would be applied at all four corners. Either the two unit or the single-unit locomotive and idler car will, of course, require contact shoes at each corner of the equipment.

The steel plant yard probably represents the hardest service of any industrial haulage. Its collector system is also subjected to a comparable service. The insulator and protective insulation must withstand hot metal and slag spillage. It must also be substantially built to withstand mechanical injury from spillage, and from badly-loaded refuse or scrap cars.



Sketch showing the arrangement and location of the third rail at switches and crossovers.

About 1,900 feet of under-hung bottom contact third rail was placed in steel mill yard service in a certain steel mill May 31, 1923. This is a 250-volt straight electric installation, current being supplied through automatic reclosing circuit breakers from the existing power system. The installation of the third rail cost $2 per ft., distributed as follows:

Rail	17	per cent
Insulators	12	" "
Guard	10	" "
Brackets	5	" "
Bonds	5	" "
Miscellaneous bolts, wire, etc.	11	" "
Labor	40	" "

As most of the work was pioneering and done at odd times, it is felt the figure on labor could be bettered on future work. The accompanying sketch shows the arrangement of the third rail for switches and crossovers. With the exception of the bakelized canvas insulator, all the material was produced or fabricated in this plant. The rail is a "bullhead" section of 3-in. x 3-in. soft steel billet which lends itself readily to bending in order to follow the track curvature. The supporting bracket is a piece of ¾-in. by 8-in. sheet bar, bent to the shape desired. The wood guard fastened together by bolts and rails is easily built by any rough carpenter.

The center line of the third rail is located 34 in. from the center line of the track and its conducting face 2¾ in. above. With practically nothing hot but the bottom surface, with a voltage that most plant employes are more or less familiar with, because of handling drag wires on locomotive cranes, crabs, and so on, it is felt that the hazard of severe accidental shock is reduced to the minimum. In fact, after three months' service in the most crowded section of the plant yard where clean-up gangs work quite often there have been no cases of flashes or shocks reported to date.

Three months' operation of the third rail on hot metal work has resulted in only two failures, one from the derailment of a truck which required repairs to both track and third rail, and the other from grounding of a rail insulator by hot metal spillage. This failure presented a point that had been overlooked and was later remedied by the addition of one more piece of wood guard. From results obtained so far it would appear that the adop-

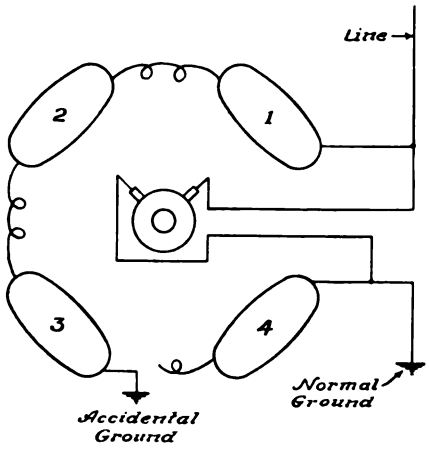
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tion of a third rail over the entire plant would be satisfactory with possibly the addition of cable reels for use on open-hearth charging floors and shops where the physical location of the rail may be objectionable. The locomotive used on this installation is a homemade rigid frame motor car to which two 75 hp. (½ hr. rating) back-geared, mill-type motors were adapted. F. O. SCHNURE.

Electrical Engineer,
Bethlehem Steel Co.,
Sparrows Point, Md.

Grounded Field Coil Connection Increased Motor Speed

SOMETIMES it appears to take very little to render a motor inoperative; how a motor can, at other times, operate under existing conditions is a wonder. We had a 600-volt, 4-pole, direct-current, shunt-wound motor driving a blower for supplying the air for twelve down-draft blacksmith forges. One day the foreman of the blacksmith shop remarked that "the air is much better than it used to be." As the improvement was attributed to general improvement in voltage conditions, no attention was paid to the remark at the time. A few days later, however, the maintenance man having occasion to lace the belt which connected the motor to the blower, noticed that the armature turned faster than usual, the frequency of the sound made by the lacing as it passed over the pulley of the blower calling the higher speed to his notice at once. No sign of sparking appeared at the brushes, vibration appeared to be even less than usual and there was absolutely no throwing of oil. There was no outward indication of trouble excepting the noticeably higher speed, notwithstanding the fact that the motor operated in a dark place where an increase in sparking would have been readily noticed. Investigation disclosed the condition indicated in the accompanying diagram. One side of the motor was normally grounded, as it was a ground return circuit. Between the normally grounded field coil, No. 4, and the coil



Field coil No. 4 was cut out by the accidental grounding of the connection between it and No. 3 field coil.

next to it, No. 3, the connecting wire had been forced loose, probably by someone stepping on it, and its bared end was making good contact with the motor frame, thereby cutting out No. 4 field coil entirely.

The armature was of the series-connected type, having only two paths through it from brush to brush. Had it been of the multiple-connected type, having as many paths as poles, undoubtedly the resulting unbalancing of armature current among the several paths would have caused vicious sparking.

Brooklyn, N. Y. J. A. HORTON.

Keeping Belt Operation Records in Industrial Works

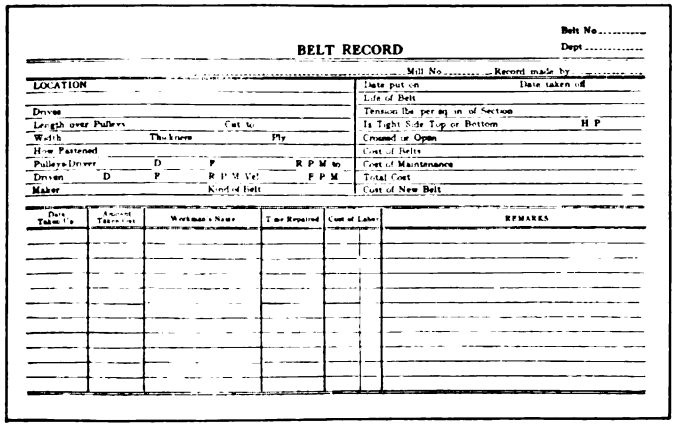
KEEPING record cards on belt operation and life is not at all new but for some reason or other it is a practice that has not been adopted by anywhere near as many industrial plants as could do so with profit. Transmission belting has so much to do with production that every superintendent should have a recorded knowledge of the service that may be expected of various types and grades of belts on different classes of drives. It is not necessary for him to keep a card for every belt in his works but he should at least keep a record or two of every class of belt drive and should always keep records of larger or more costly installations. In this way it is not only possible to know what the different belts are doing but such a record also facilitates the comparison of two types or grades of belts. All lines of industrial work do not require the highest-grade belting. However, without some record it is not always practicable to judge whether the second grade of belting will be satisfactory. Whenever the belt record shows that a belt has a very short life it indicates the need of locating the cause.

Belt records gather performance data which aids industrial men in selecting the best belt for any special service.

Plant operatives who desire to keep belt records may secure a supply of belt record cards upon request from many of the prominent manufacturers of leather belting. The cards shown accompanying this item may be obtained from the Chicago Belting Company, Chicago, Ill. These are standard 8-in. by 5-in. cards and provide ample space for record purposes. These forms have been tried out in practical applications.

Much has been said about belt tests and belt quality, but it is the service on the pulley that really counts. Conservative estimates indicate that the average plant can reduce its belting costs about 25 per cent. This can be obtained through care of belts after they are installed and judgment in selection based upon the knowledge of actual conditions that may be obtained from record cards such as these. E. D. F.

Chicago, Ill.

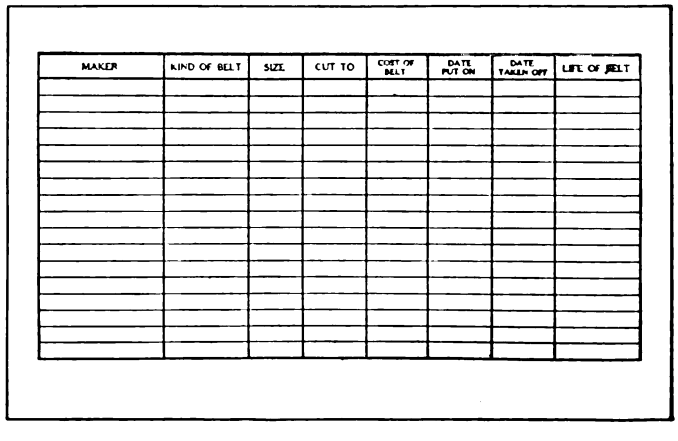

BELT RECORD

Belt No.....
Dept.....
Mill No..... Record made by.....

LOCATION
Drives
Length over Pulleys Cut to
Width Thickness Ply
How Fastened
Pulleys-Driver D F R P M to
Driven D F R P M Vel F P M
Maker Kind of Belt

Date put on Date taken off
Life of Belt
Tension lbs. per sq. in. of Section
Is Tight Side Top or Bottom H P
Crossed or Open
Cost of Belts
Cost of Maintenance
Total Cost
Cost of New Belt

Date Taken Off	Amount Taken Out	Workman's Name	Time Required	Cost of Labor	REMARKS



MAKER	KIND OF BELT	SIZE	CUT TO	COST OF BELT	DATE PUT ON	DATE TAKEN OFF	LIFE OF BELT

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A Switchboard Which Simplifies Testing Motors by the Pump-Back Method

A SWITCHBOARD for testing alternating-current and direct-current motors and generators by the "pump-back" method has been in use for several years in the plant of an eastern motor manufacturer. The switchboard controls a 230-volt direct-current machine of about 75 kw. rating. This machine is belted to the machine to be tested and acts as a generator if the tested machine is a motor, and conversely, acts as a motor if the tested machine is a generator. Two field rheostats are provided for the 75-kw. machine. The high-resistance rheostat permits the machine to be used as a motor at its highest safe speed. The low-resistance rheostat permits fine adjustment of speed when running as a motor and fine adjustment of load when running as a generator. A no-voltage release acts as a safeguard.

If the motor to be tested is a direct-current motor, it is connected to the leads marked *A*, *F*, and *M* (armature, field, and main) at the bottom of the board. The motor to be tested may be either 115, 230, or 550-volt, as all three sources of supply are provided on top of the board. The 230-volt, 115-volt, and 550-volt direct-current generators supplying this energy are driven on the same shaft by a synchronous motor, so that no matter what combination of voltages are used, all power above that required to supply losses is pumped back in the line. Only one of these switches can be closed at a time or a short circuit will result. However, as only one motor can be under test, there is very little danger of two switches being closed at the same time. The two studs *F'* and *F''*, which are in series with the field lead, are used for inserting a field rheostat. A permanent field rheostat on the board would not provide sufficient flexibility where various sizes and types of motors are tested.

After the motor under test is connected up and proper pulleys have been selected for both the motor and generator, one of the three top switches is closed, depending on the voltage of the motor under test. The double-throw switch *R* is then closed to the testing position, which places the starting resistance in the armature circuit of the motor under test. The same starting resistance is used for both the motor under test and the generator. The motor is then brought up to speed and the test switch *SC* (short-circuiting) closed. The rotation should be checked to see if it is correct and changed if necessary.

By changing the double-throw switch *R* to the "generator" position and closing the 230-volt generator switch, the generator can be placed on the line using the starting resistance. The load on the motor is watched, adjusting the generator field rheostat if necessary, to keep the load down. When the generator is on the line the load can be accurately adjusted. Portable instruments are used on the motor under test, as they are more accurate and flexible than instruments placed on the switchboard. It is not necessary to measure the load on the generator.

There are rare cases where the proper pulley combinations cannot be obtained to drive the generator at the correct speed for putting on the line and loading. In these cases the studs marked *L*, *L'* are connected to an external variable resistance for loading the generator. The 230-volt generator switch and the main switch with no-voltage release is closed so that the generator field is excited from the main line. All the power generated is, of course, in these cases, dissipated as heat and is a loss. It is, however, seldom necessary to resort to external loading, as by far the greater majority of cases can be loaded by the pump-back method in which only the losses of the motor under test and the generator have to be taken from the line.

Alternating current for testing an induction motor is obtained from a motor-generator set (not shown in the drawing) which consists of a direct-current motor driving a 60-cycle, alternating-current generator. The motor is driven from the direct-current main and is so arranged that it can be driven either from the 230-volt or the 115-volt supply which, with field weakening, provides various speeds so that motors of all ordinary frequencies can be tested from the same generator. In addition, the generator connections are brought to a terminal board provided with switches, so that the windings can be connected in series or in parallel and each combination can be connected either in star or delta. With field-excitation control, this gives a wide range of voltage.

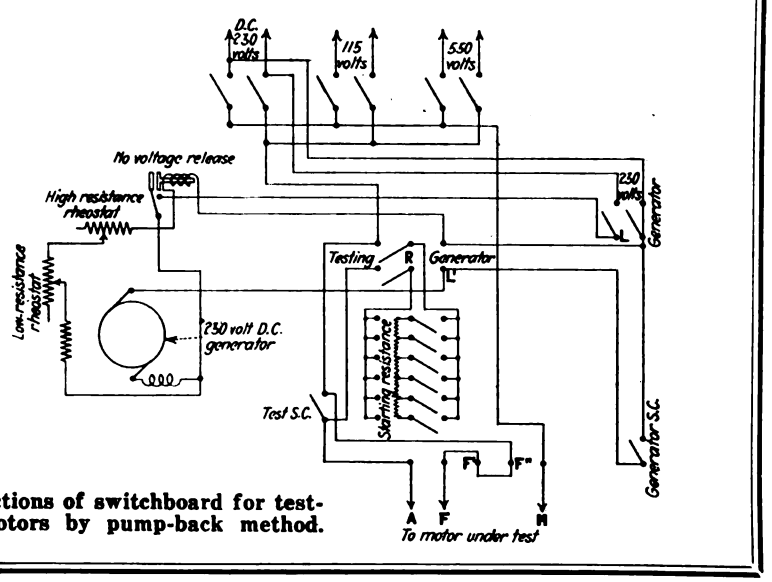
In loading an induction motor it is necessary to note the pull on the belt, that is, which side of the belt should be tight when the motor under test is doing work as a motor, because only in this way can one tell whether the motor is running as a motor or an induction generator. The ammeter reading on the induction motor is the same whether the motor under test is doing work as a motor or a generator. With a direct-current motor the ammeter shows a reversed reading.

In testing a direct-current generator, it is driven by the 75-kw. machine and pumps energy into the line at 115, 230 or 550 volts, as desired.

An alternating-current generator likewise is driven by the 75-kw. machine and is loaded by connecting it to the alternating-current side of the motor-generator set.

EUSTACE C. SOARES.

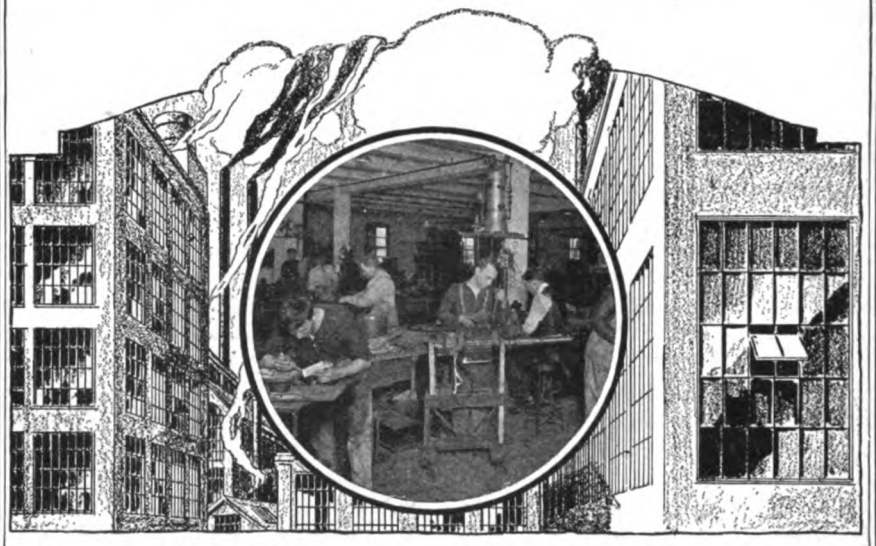
Electrical Engineer,
Ophuls & Hill, Inc.,
New York City.



Connections of switchboard for testing motors by pump-back method.

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In the Repair Shop



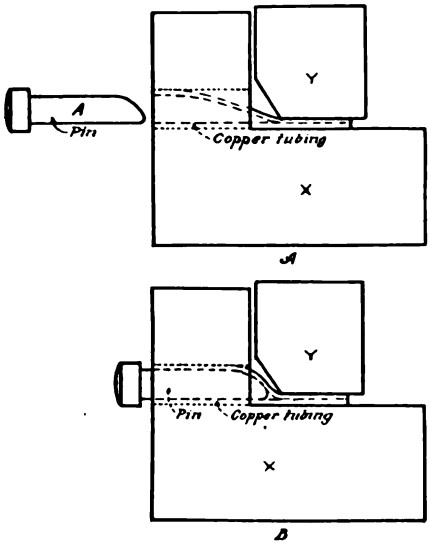
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Terminals Made from Copper Tubing in Emergency

WE RECENTLY had occasion to use a number of copper cable terminals and were not able to secure them on short notice. In order not to hold up the work under way one of the instructors made the device shown in the accompanying illustration and then secured some copper tubing from a plumber and made the terminals. As shown, the block x is an L-shaped piece of cast iron through which was drilled a hole just large enough to receive the copper tubing and located so that one side came through flush with one of the inside surfaces of the L. A square cast-iron block y was finished off with a beveled edge. Lastly a steel pin was made of the shape shown and of the proper size to fit inside the tubing.

The tubing was cut into suitable lengths with a hacksaw. To form a terminal a length of tubing was inserted in the drilled hole until it was flush with the left-hand side of the block. Blocks x and y were then clamped in a vise to flatten one end of the copper tubing. This made the tube assume the form shown in *A*. The steel pin was then driven in the tubing to form the socket to its full diameter throughout the length of the portion in the hole. After the terminal was taken from the form a hole was drilled for the bolt, the ends were ground, and the inside of socket was trimmed. HARRY S. RUSH.

North Dakota Agricultural College, Agricultural College, N. D.



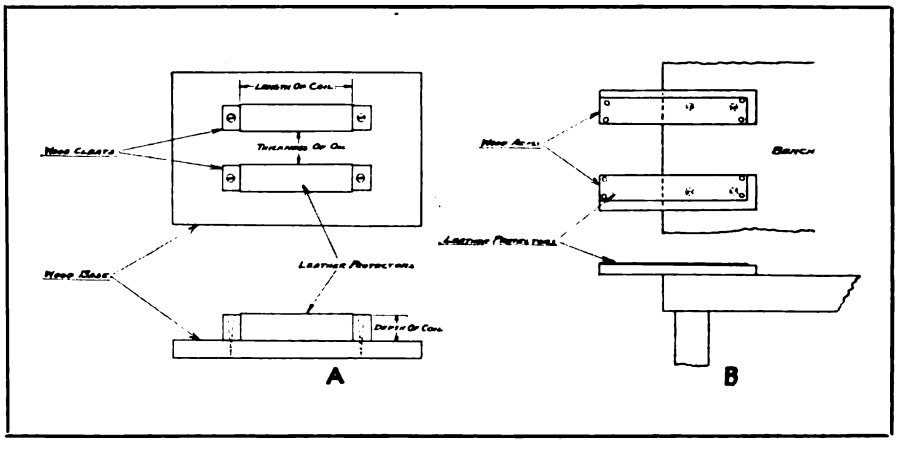
The tubing was cut into suitable lengths, flattened at one end in the die and the socket formed by driving the pin into the other end.

Fixtures to Hold Field Coils While Being Taped

IN THE winding department of an Eastern manufacturing company, the taping of large motor field coils is expedited considerably by the use of the two fixtures illustrated and described below. Either one might well be adopted by the repair departments of factories or shops where the taping of a field coil on an ordinary bench is always an awkward job.

The first fixture, shown in *A*, consists of two cleats made of heavy wood, which is well seasoned to prevent warping or splitting, mounted on a wooden base. The cleats should be covered with leather. The dimensions are in proportion to the sizes of the coils handled. By using large, flat-head wood screws to hold the cleats the space between them may be adjusted to take coils of varying thickness. The coil is placed on its side between the two cleats where it is held firmly upright in a convenient position for applying the tape. When not in use the fixture is easily set back off the work bench out of the way.

Where a certain part of the work bench may be permanently set aside for taping field coils, the arrangement shown in *B* is very useful. In using this device the coil is laid flat on the two arms, spanning the space between them. It is moved around as the taping progresses. The two arms project out only a short distance—just far enough to permit the roll of tape to pass between the edge of the bench and the inside of the coil. The thickness and width of



These devices will speed up the work of taping field coils.

The fixture in *A* consists of two adjustable cleats fastened to a wooden base. The coil is placed on its side between the cleats. In *B* two wooden arms are fastened to the bench and the coil is placed across them for taping. The arms can be adjusted to hold coils of different sizes.

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the arms are made to suit the sizes and weights of coils ordinarily repaired. The arms, being fastened to the bench with screws, are adjustable for various widths of coils. This device, where it is possible to use it, is preferable to the other because it places the coil on a better working plane and enables the operator to drop the roll of tape naturally downwards through the coil in making the round of the coil.

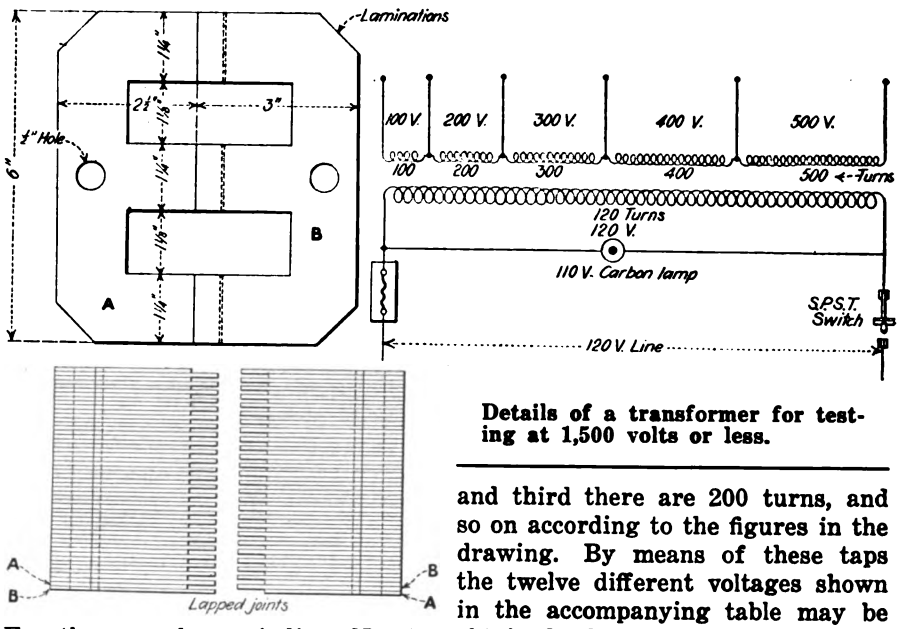
Honesdale, Pa. J. M. WALSH.

Construction Details of Transformer for High-Voltage Tests on Small Motors

THE transformer shown in the accompanying drawing and photograph was made for use in high-voltage tests on small motors. This transformer gives from 100 to 1,500 volts, with ten intermediate voltages.

For the core, laminations were secured of the shape shown in the drawing. One-half of these laminations are of the dimension shown at *A* and are 2½ in. wide, while the others are of the dimensions shown at *B*, and are 3 in. wide. The laminations were built up to a height of 4 in. One-half of the core was built at one time, the *B* laminations alternating with the *A* laminations. After the two halves were built up, they were bolted together with ⅜-in. bolts and the coils were put in place. Then the halves of the core were shoved together.

For the primary winding, a coil was made up of 120 turns of No. 16 gauge double-cotton-covered wire.



Details of a transformer for testing at 1,500 volts or less.

For the secondary winding, No. 26 double-cotton-covered wire was employed. Altogether, there were 1,800 turns on the secondary winding. Six taps, including the end terminals, were brought out, as shown in the drawing. Between the first terminal and the second tap, there are 100 turns; between the second and third there are 200 turns, and so on according to the figures in the drawing. By means of these taps the twelve different voltages shown in the accompanying table may be obtained. In bringing out any tap, the wire should be insulated with a varnished cambric sleeve, if this tap is to be covered by further layers of wire. The core itself should be insulated from the winding by fiber or fishpaper, and the primary coil should be insulated from the secondary by the same material.

Taps for Different Voltages

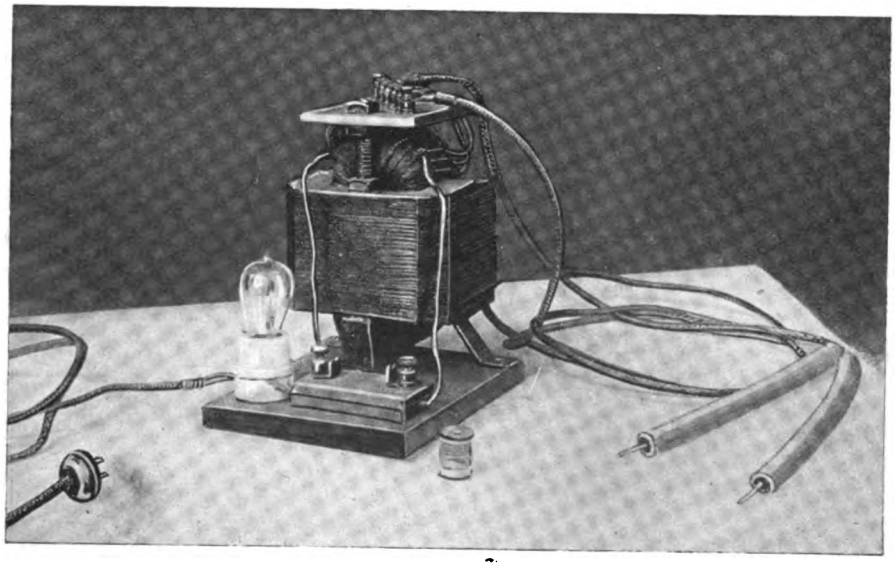
Voltage Desired	Connect High-Voltage Leads to Taps Shown Below
100	1 and 2
200	2 and 3
300	3 and 4
400	4 and 5
500	5 and 6
600	1 and 4
700	3 and 5
900	4 and 6
1,000	1 and 5
1,200	3 and 6
1,400	2 and 6
1,500	1 and 6

After this transformer was built it was mounted upon a baseboard and another board with terminal posts for the secondary was mounted above the coils. In series with the primary side, a fuse block for using an open fuse wire was connected. Across the primary terminals a 110-volt carbon lamp was connected. This lamp is a safety feature, as it is lighted whenever there is voltage on the primary side. The primary leads were connected to a flexible cord having on its other end a detachable plug to fit in an ordinary 110-volt outlet. The secondary leads were flexible, heavily insulated wires. The high-voltage terminals were wires which were wrapped with varnished cambric and outside of this was placed rubber tubing.

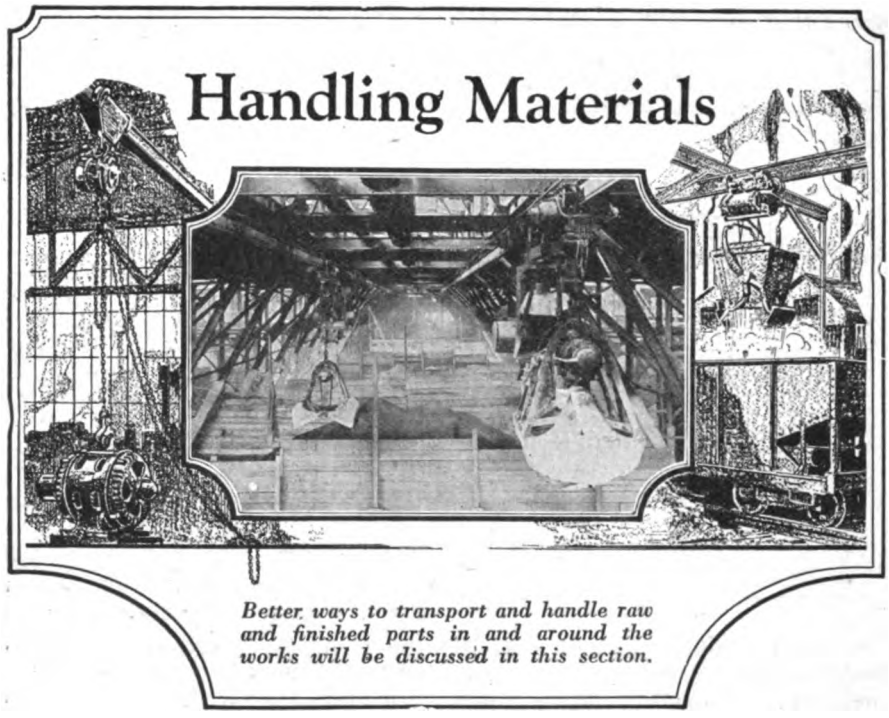
In operation, if a ground or short circuit is detected by the secondary leads, the fuse blows. On touching the secondary terminals to the conductor and frame and removing them, a light blue snapping spark indicates only charging current and does not show a fault. A red or yellow flaming spark, however, shows that power current is passing and that a short circuit or ground exists, depending upon what is being inspected. Usually when there is such a short circuit or ground the fuse will blow. A. C. ROE.

Detroit, Mich.

This transformer was made for testing for grounds and short circuits with voltages of from 100 to 1,500 volts.



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Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

An Electric Truck with High Wheels Which 1s Adapted for Inside Haulage and Also for Street Industrial Use

INDUSTRIAL plants which have much yard work, or where it is necessary for the truck to go some distance on the street, often find that an electric industrial truck with larger wheels than is ordinarily used on concrete driveways or factory floors gives better satisfaction. For example, the New York City plant of the International Tailoring Company uses such a truck to handle material in the plant and also to carry the mail to the post office a block away.

This company does a mail order business with thousands of retail tailors throughout the country. They send out large numbers of sample books, measuring charts and finished garments as well as a large amount of other mail. The volume of the parcel post became so great that three or four men with as many hand trucks had been required to take the mail to the post office. Finally, an electric industrial truck (Crescent Truck Co., Lebanon, Pa.), as shown in accompanying illustration, was installed. This was fitted with a special body, mounted on the platform of the truck, to take care of the mail bags. This body is made of steel and has a hinged door which opens into the single deep compartment. The truck body was designed to fit inside of the freight elevators of the building and is taken on to the elevator and carried to the ninth floor for its first consignment of mail in sacks. It is then lowered with its partial load to the shipping and cutting rooms on the second floor, where it picks up the packages of garments which are packed and ready for mailing. It is then run onto the elevator and lowered to the street level, the hinged door locked and it goes on its trip to the post office. This truck carries about thirty-five sacks per trip and ordinarily makes four or five trips per day. Frequently, when the mail is extra heavy, a trailer is attached. In this way one man has replaced the three or four formerly required for this work with a corresponding saving.

The truck used here is of 4,000 lb. capacity and has an extremely short body with an overall length of but 64½ in., which enables it to be used on a 66 in. elevator. Many plants, particularly the older ones, have small elevators and so are limited in the size of truck which can be used. This truck is also comparatively light, which is an additional advantage in using on elevators in the older type of buildings. The truck wheels are 20 in. in diameter with hard rubber tires which permits them to be used in the yards or on the street.

As may be noticed, when it is used on the street a truck of this sort must carry a regular commercial truck license. The batteries are guarded against damage by having coiled springs surrounding push rods on each side of the cradle which carries the battery. This eliminates much of the jar of the rough street pavements, thereby lessening the



This truck, with a special body is used to carry mail about a block, to the nearest post office. It also has an extra short body which enables it to be run onto the elevator and taken to the ninth floor for loading.

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danger of damaging the battery.

Trucks with large wheels such as this are advantageously used in handling material over rough or loose ground. Of course, it is not possible to haul as large loads as if the yard were smooth concrete.

Lifting Mechanically the Unhandy Loads Without Blocking Up

ORDINARILY if a load is to be carried by truck it must either be placed upon a platform to be handled by lift trucks, either hand-operated or electric, or the loads must be raised bodily and set upon the truck. Some manufacturers now, however, are taking advantage of electric lift trucks which pick up and support the load on fingers extending out from the front of the truck. These may be raised and lowered as is the platform of an ordinary electric industrial truck, but their bottom position extends entirely down to the floor. The points of these fingers are chisel shaped at the outer end so that they may be inserted beneath a bundle, box, barrel, casting, or any other irregular shaped piece weighing up to 2,500 lb., and lifted clear of the floor. With this, it is not necessary to lift the weight entirely but merely have it resting even on narrow planks or tip it enough so that the chisel points can be pushed under.

One plant, for example, uses a truck of this sort (The Elwell-Parker Electric Company, Cleveland, Ohio) to carry crated goods, as shown in the accompanying illustration. The cleats hold the package



This truck has fingers or projections extending out in front which are run under packages and raised to carry the load.

up far enough from the floor so that the fingers may be slipped underneath, the load raised, and carried to its destination. The length of the fingers in various trucks depends largely upon the type of material to be handled, as it is not best to get them too long because the load on the truck is balanced over the front wheels against the battery box and the remainder of the truck.

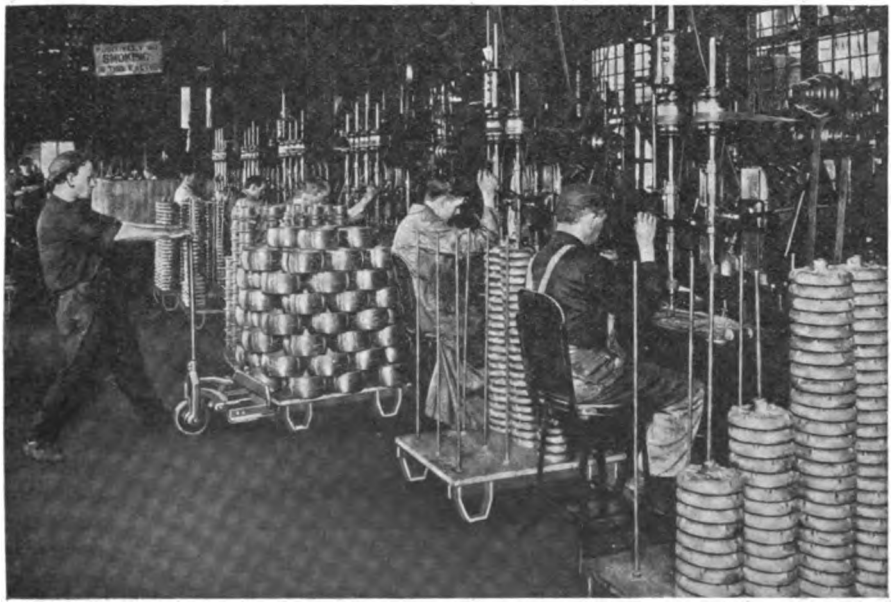
Bulk Handling Which Simplifies Movement to and from Machines

PROBABLY but few factories still use the old plan of dumping castings at one side of the machine for the operator to pick up, machine, and throw on the floor again at the other side. The unnecessary re-handling incidental to this was one of the earliest problems attacked in solving material-handling difficulties in industrial plants. It is now the practice in many plants where the work flows from one machine to another in a regular procession to place permanent benches between or, in some cases where the distance is greater, conveyors from one machine to the next. This plan, however, is only adaptable where there are but few changes in the work operated on by that one battery of machines.

In plants where a diversity of work may be handled by each of the machines, skids or platforms for hand or electric elevating trucks now generally take the place of the permanent benches, as is shown in the accompanying illustration. This illustration, taken in the drill-press department of a large electric motor manufacturer, shows one solution of this problem. Here the material is piled on these platforms and deposited beside the drill-press operator or removed when finished, by a "Transveyor" (Cowan Truck Co., Holyoke, Mass.).

Material which does not pile easily is stacked on spindles as shown. In some cases a filled platform of unfinished work is placed on one side of the operator and an empty platform to receive the finished work is placed on the other. However, with these trucks this is not always necessary. For example, one or two empty spindles may be left on a truckload of unfinished work to receive the pieces as they are finished. In this way the same platform may be used for both finished and unfinished work and so decrease the amount of floor space necessary between the machines. Where floor space is at a premium this saving is considerable. Also, in case of an emergency, the whole load may be removed and an entirely new line of work substituted if it should become necessary to change the piece on which the man is working.

In addition, this material, in case the man performing the next operation is not ready, may be stored on the truck platform until he is ready and thus eliminate any extra handling between operations. Methods such as this also help to keep a shop in order.



How a large electric motor manufacturer simplified the handling of miscellaneous work from machine to machine in the drill-press department.

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Stubbing and Connecting Windings

(Continued from page 539)

found that lights out. Then mark these two leads as belonging to the same section and repeat until all four sections have been located.

The next step is to locate the two sections of one phase. Take any one motor lead and if it cannot be traced by the eye to the group it connects to, use the test light. Hold one test lead on the motor lead selected and with the sharp-pointed test lead test each group until a light is obtained. Then call this group No. 1 and counting over to the right to No. 3, test this group while holding the other test lead on the same motor lead as before. The test lead can be attached to the motor lead with a piece of tie wire. If a light appears on this No. 3 group, it is the second group of the first section. If no light appears then count over to the left to No. 3 and test. If a light appears then *this* is the second group in this section. Mark the two leads which connect to this section, leads 1 and 5.

A light on either of these No. 3 groups (to right or left) shows that the winding has a top-to-top or short-jumper connection. It is possible that neither of these groups will show a light. This would indicate that the winding has long jumpers (top-to-bottom connection). In this case the test should be made on group No. 5. A light on this group will show that it is the second group in the section.

Now that one section is located, the next step is to find the other section of the same phase. With the top-to-top connection this is done by starting at the last group in the first section which has already been located. Start on this group as No. 3 and pass from 3 to 5. The group 5 so found will be in the other section of the same phase. Keep the sharp point on this group and locate the two leads which are connected to it. Mark these leads 7 and 3. These four leads then, 1 and 5 and 7 and 3, locate one phase.

Now in order to be sure of correct connections later, the leads must be marked according to some diagram like that in *M* of Fig. 6. Taking the first section located face the machine and call one group of this section No. 1. One lead of this group will connect to one motor lead. Pull on this group lead until it can be located outside the motor. Mark this lead No. 1 and its mate No. 5. Then from group No. 3 count over to group No. 5. By pulling locate the motor lead which connects to this group. Mark this lead No. 7 and its mate No. 3. This gives one phase in its proper relation. Locate the second phase leads in the same way, marking according to diagram.

On a six-pole, two-phase motor there would be three groups per section instead of two as in the case just mentioned. Similarly there would be four on an eight-pole machine, five on a ten-pole, and so on.

In checking a three-phase, star winding the diagram in *N* of Fig. 6 may be followed as an example. Such a winding has nine leads. The winding is divided into four sections, one section has three leads and the other sections have two leads each. With the test lamp find the three leads belonging to the large section. Then keeping one test lead on one of these leads locate one of the groups in this large section. By pulling trace out this section until one of the motor leads connecting to the section is found. In a four-pole machine there are six groups in such a section; there are nine in a six-pole machine; twelve in an eight-pole machine, and so on. Then all the groups in this phase may be located as they are all separated by two groups belonging to the other two phases. By tracing around in this way the other section in this phase is located. Then by referring to the diagram the various leads may be marked as they are in *N* of Fig. 6.

The delta winding as shown in *O* of Fig. 7 is divided into three sections each having three leads. The first step is to light out the motor leads into three sections. The next step is to find the lead which has two groups connected to it. Take any lead of any section and with the test lamp locate a group in this section. By pulling follow up the groups in this section until the lead attached to two groups is found. Call this lead No. 1. Then by pulling the leads the other groups can be located. By working in this manner while consulting the correct diagram the entire winding may be checked and marked.

A winding arranged for star-delta connections like that in *P* of Fig. 7 is easy to check. There are three sections and each section contains all the groups in one phase. With the help of the test lamp the six leads should be divided into

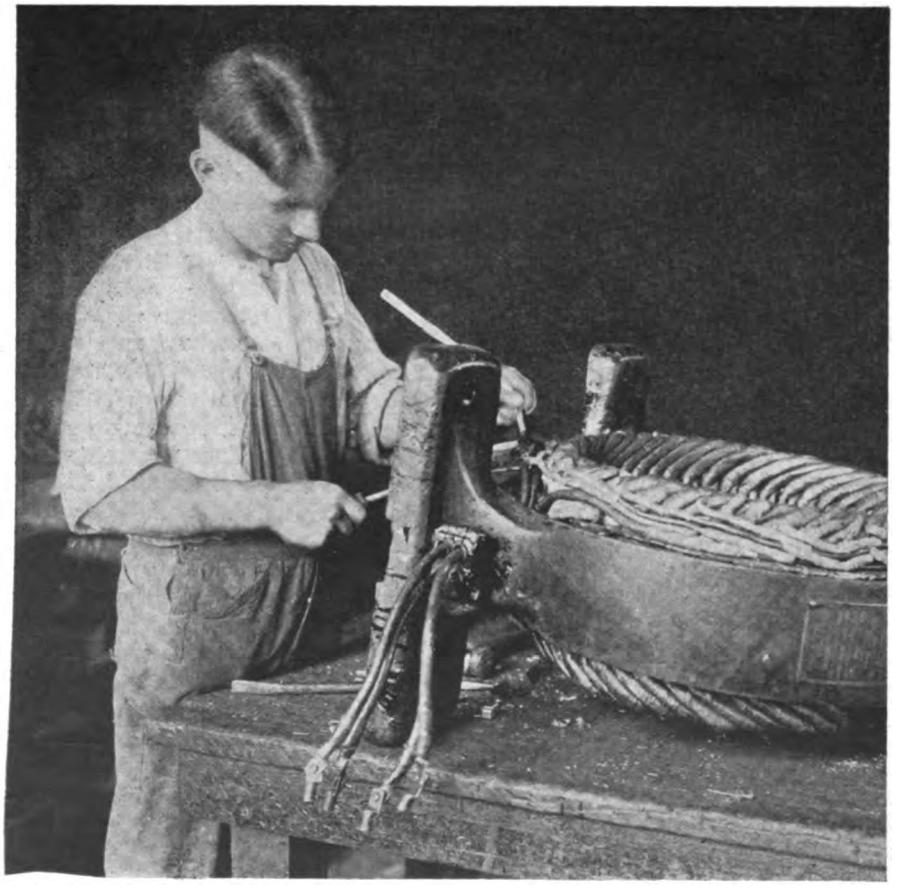


Fig. 8—After soldering the jumper connections they are taped and formed as shown in *E* of Fig. 2.

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three sets of two each. The groups of each section should be located by means of the pointed test lead. Then the diagram should be consulted with particular reference to the direction of the arrows. In place of arrows chalk marks may be made upon the stator core to represent direction of current flow. These should be straight marks made at each group and inclined inward in the direction in which the arrows point. After these marks are put on, the leads should be marked according to the diagram. If one of the phases is reversed the winding will have a "60-degree" connection instead of the correct "120-degree" connection. An explanation of the difference between these two kinds of connections is given in the article on page 491 of INDUSTRIAL ENGINEER for October.

Those who want to learn another method of testing out the double-voltage windings may refer to an article on "Connecting Induction Motors with Untagged Leads to the Line" by L. G. Tubbs in the November, 1922, issue of *Electric Journal*.

In a later article of this series in INDUSTRIAL ENGINEER explanations and diagrams will be given of two-speed and four-speed windings.

Circuit Breakers for D. C. Motors

(Continued from page 528)

shunt-trip coil of the second circuit breaker. When the first breaker opens the auxiliary switch will close and thus operate the shunt trip.

If desired the auxiliary switch can be so constructed that it closes the local circuit when the breaker is closed and opens it upon the opening of the latter. This form of switch is frequently used on a circuit breaker when it is desired that the opening of the same shall cause the opening of a second circuit breaker having a no-voltage coil. In this case the end in view is attained without the use of a shunt-trip feature by having the circuit of the no-voltage coil connected through the switch on the first or control instrument.

The instances cited will serve to indicate the manner in which these auxiliary switches or bell-ringing attachments may be employed to meet a variety of conditions.

Fig. 9 shows this auxiliary switch connected into a local circuit, so as to provide an alarm whenever the circuit breaker opens. While in the illustration a bell is shown as the indicating means, a semaphore, lamp, or other suitable device may be substituted to meet the requirements of the user. The indicator, whatever form is employed, may be located at any required distance from the circuit breaker, or several indicators may be placed at convenient points.

How to Keep Circuit Breakers in Proper Condition

Keep the joints and contacts of circuit breakers clean and tight and they will usually give no trouble. If a joint shows signs of heating (darkening of the copper) it should be tested. Heating may usually be traced to insufficient copper or poorly made joints at the back of the instrument; or it may be due to oxidation of the contacts resulting from lack of use.

The condition may readily be investigated by going over the joints in question with a milli-voltmeter or, if none is available, a Weston round-pattern ammeter (disconnected from its shunt) may be employed. The full scale of these instruments when used in connection with the leads supplied by the maker is approximately 0.050 of a volt, and the instrument may readily be equipped for the work in question by attaching a sharp needle point to the free end of each lead.

Where cables are attached to the circuit breaker by means of lugs, the joints associated therewith should be made the subject of especial scrutiny. Generally speaking, no single joint should show a drop over 0.003 of a volt when subjected to its rated load. The oxidation which may form on the circuit breaker contacts through lack of use and in the absence of self-cleaning action incident to frequent opening and closing, may readily be removed by the application of fine emery cloth to the surfaces affected.

When heating does occur, even though the causes be external to the circuit breaker, if these are not hunted up and removed the spring temper of the laminated member will be damaged and thereby introduce a further source of heating. Where this has been allowed to occur the installation of a new laminated member is the only remedy, and after this is installed its adjustments should be tested by means of the milli-voltmeter method described.

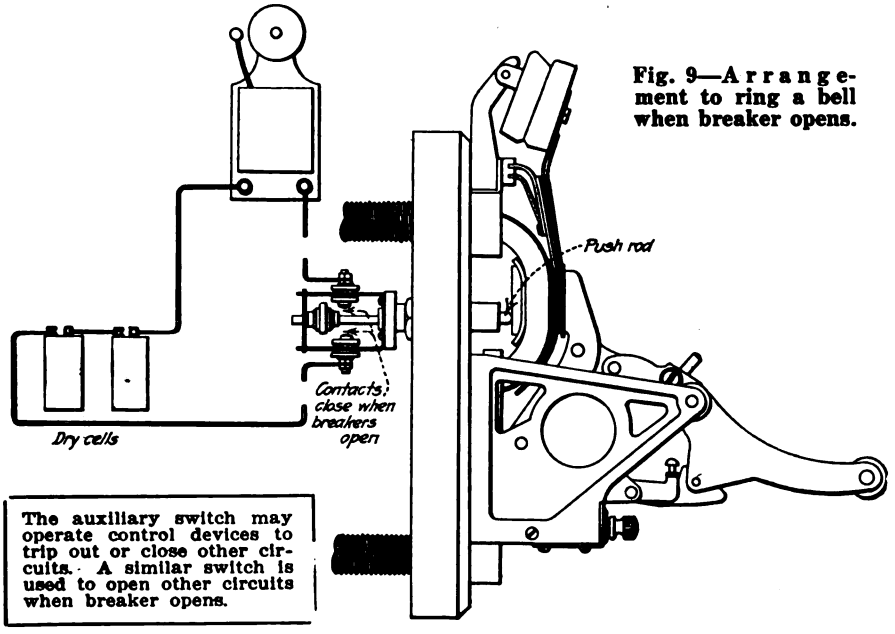


Fig. 9—Arrangement to ring a bell when breaker opens.

The auxiliary switch may operate control devices to trip out or close other circuits. A similar switch is used to open other circuits when breaker opens.

Installation and Care of Motors

(Continued from page 544)

as the commutator. If sandstone is not easily obtained, sand paper may be used by pressing it against the surface of the commutator with a block of wood shaped like the sandstone mentioned above. In both cases, the commutator should be run at a high rate of speed during polishing and the sandstone or sand paper moved back and forth along the surface parallel to the shaft. After this has been done, the commutator and brush faces should be carefully cleaned to remove any grit which might cut or scratch the com-

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mutator. Emery cloth should never be used on a commutator or brush.

Slip Rings.—It is advisable to apply a little clean lubricating oil to the collector rings regularly. The oil may be applied with a piece of cloth or chamois skin.

Heating.—When a machine appears to be too hot to the touch, the actual temperature should be measured with a thermometer. The safe operating temperature of a motor or generator cannot be accurately determined by the hand, as it is impossible to hold the hand comfortably on a motor which has been heated to within its guarantee. The temperature rise for which a machine is guaranteed at its rated load is shown on its nameplate. The guarantee is based on the surrounding air temperature, assumed at 40 deg. C. (104 deg. F.) or less and the machine can be operated safely if its temperature by thermometer does not exceed 90 deg. C. or 194 deg. F.

Types and Kinds of Flexible Couplings

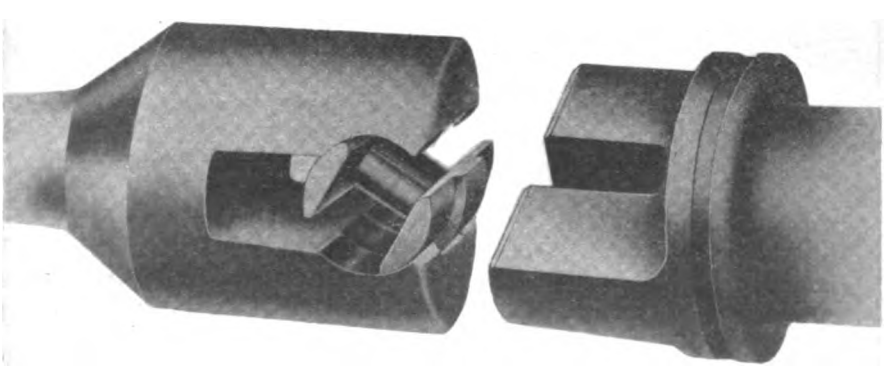
(Continued from page 533)

power at a varying angle rather than to take care of any off-center misalignment or endwise movement. To take care of any out-of-center misalignment with the universal-joint type of coupling, it is usually necessary to employ two such joints connected by an intermediate shaft. When it is necessary to provide for end-wise motion in addition, some external means must be employed, such as a splined shaft or some other modification.

Flexible couplings of the universal-joint type employing leather or steel disks are quite usual in the smaller sizes for some work and have been used even for larger work where two such joints are in combination to take care of out-of-center misalignment. Such combinations form an effective flexible coupling provided extreme accuracy is used in the making.

The points to be considered when specifying flexible couplings as well as a method of checking their alignment, when installed as well as rechecks at frequent periods after they have been in operation, will be discussed later in a continuation of this article.

EDITOR'S NOTE: Special acknowledgment is made to John J. Serrell, Smith & Serrell, Newark, N. J., and to the following companies for their kind assistance in furnishing information, counsel and illustrations for this and the other articles which appear in this series: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; The Bartlett Hayward Co., Baltimore, Md.; Charles Bond Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; Brown Engineering Co., Reading, Pa.; The Carlyle Johnson Machine Co., Manchester, Conn.; Chicago Pulley & Shafting Co., Chicago, Ill.; Conway & Co., Cincinnati, Ohio; The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; I. H. Dexter Co., Goshen, N. Y.; Dodge Manufacturing Co., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; General Electric Co., Schenectady, N. Y.; The Hanson Clutch & Machinery Co., Tiffin, Ohio; The Hill Clutch Co., Cleveland, Ohio; The Hilliard Clutch & Machinery Co., Elmira, N. Y.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Medart Co., St. Louis, Mo.; Mesta Machine Co., West Homestead, Pa.; R. D. Nuttall Co., Pittsburgh, Pa.; The Pusey & Jones Co., Wilmington, Del.; Reeves Pulley Co., Columbus, Ind.; R. H. & F. M. Roots Co., Connersville, Ind.; A. L. Schultz & Son, Chicago, Ill.; Smith & Serrell, Newark, N. J.; Thomas Flexible Coupling Co., Warren, Pa.; Weller Mfg. Co., Chicago, Ill.; Western Engineering & Mfg. Co., Chicago, Ill.; The Williams Foundry & Machine Co., Akron, Ohio; T. B. Wood's Sons Co., Chambersburg, Pa.



A disassembled view of the universal joint type of flexible coupling sometimes used in steel mill work.

American Sugar Refining Company

(Continued from page 522)

operation of the factories that make the raw sugar. In these two factories 1,450,000 tons of cane are pressed to produce 160,000 tons of raw sugar, which makes cargoes for 40 ships. This amount of raw sugar is only 10 per cent of the total required per year by the company.

This company owns and operates six barrel factories with an annual output of 4,000,000 barrels. The material for making these is taken from the company's forests, covering over 500 sq. miles, and 113 miles of railroad have been constructed to bring the logs to the mills. Each year 700 ships dock at the different refineries of the company and discharge their cargoes which total 1,650,000 tons of raw sugar. The yearly output of the company, in sugar and syrup, amounts to about 80,000 carloads.

Formerly, sailing vessels of small tonnage brought the raw sugar in hogsheads and it was then transferred by carts to the refineries away from the waterfront. Now, ships of 10,000 tons burden land at the docks of the company, and their cargoes, with a minimum of rehandling, are dumped into the melting pan. The material is then handled by gravity and mechanical means until the finished product leaves the factory.

Although sugar is one of our important foods the industry is comparatively small. The industry ranks forty-eighth in value added by manufacture and also forty-eighth in total number of wage earners with less than 20,000 employed, according to the 1919 census. Like the meat packing and many other food products industries, the most important factor is the cost of the raw material which in this industry is over 90 per cent of the value of the finished product. Industries operating on such narrow margins must be large and handle a large volume of product at a small profit per unit. Last year's operating profit was about ¼ cent per lb. of raw sugar handled. Much of the raw sugar is imported, mostly from Cuba, and pays a tariff of 2 cents per pound. In view of the refiner's never ceasing efforts to make sugar as pure and attractive a food as possible, it is not surprising that the per capita consumption in the United States has increased from 8.8 lb. in 1823 to 103.18 lb. last year.

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Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

The Dillon Electric Company, Canton, Ohio—Bulletins 207, 251 and 307 cover heavy and medium duty self-contained, direct-connected grinders and buffers of pedestal and bench types, which are made for either alternating or direct current. The heavy-duty grinders and buffers are made in 3-, 5- and 7½-hp. sizes, while the medium-duty grinders and buffers are made in ½-, 1- and 2-hp. sizes.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio—Bulletin 313 describes the Type MSB automatic reclosing sectionalizing circuit breakers for direct current distribution systems. This bulletin gives the operating characteristics and design features, application, construction and operation of this Type MSB breaker, which is designed especially for use in direct-current distribution systems beyond the stations. It may be used interchangeably, without any modifications in the wiring or connections, to tie together feeders from the same or different stations or independent bus circuits or stub-end feeders.

Gisholt Machine Company, Madison, Wis.—Bulletin describes the "Precision Balancing Machine" which is an instrument for the accurate measurement and location of unbalance in motor and generator rotors, flywheels, crankshafts, spindles and other rotating machine parts.

R. and J. Dick Company, Inc., Passaic, N. J.—A small booklet describes and illustrates as well as gives instructions for splicing a 6-in., 5-ply "Dickbelt" endless. The joints made by several other metallic fasteners are also illustrated.

The Revolvator Company, 336-352 Garfield Avenue, Jersey City. N. J.—A small folder describes the nine standard models of revolvator piling machines which are made in capacities of 400 lb. upward and are able to pile material 6 to 20 ft. high according to requirements. This piling machine may be made to revolve on a turntable base so that it may be loaded on one side and material piled on the other by simply revolving it one quarter- or one half-way around after loading.

The United States Electrical Tool Company, Cincinnati, Ohio—Literature announces a new U. S. automatic ¼-in. electric drill recently placed on the market. This drill is of the universal type, ball bearing and possesses other advantageous construction details.

Herman H. Sticht and Company, 15 Park Row, New York City—The "Standco Megohmer," Bulletin 115, is especially adapted for acceptance and maintenance tests of low-voltage alternating and direct current motors and generators, of wiring installations, switches, switchboards, panel boards, receptacles, fixtures, railway signal equipment, and fire alarm telegraph systems. The theory on which this device operates as well as details of its construction, and instructions for use are included.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Bulletins 9843 and 9872 give the special and optional features of design, capacity limitations, information required with order, general description, construction and approximate dimensions as well as a list of standard and optional features of alternating current, full-magnetic elevator controllers, for two-speed, high-power squirrel cage and slip-ring induction motors.

Reliance Instrument Company, 1135 Van Buren Street, Chicago, Ill.—Catalog 35 describes the line of Reliance portable and switchboard ammeters, milli-ammeters, volt-meters, milli-voltmeters, volt-ammeters, milli-voltmeters, and other special instruments for testing or measuring alternating and direct current. Several pages are devoted to giving drilling dimensions of switchboard instruments and diagrams showing how to connect ammeters and voltmeters in circuits.

The Euclid Crane and Hoist Company, Euclid, Ohio—Catalog 19 describes the Euclid electric hoists, monorail trolleys, traveling cranes, and wall and jib cranes. One of the special features of this loose-leaf book is the clearance drawing which gives the dimensions and installation allowances necessary for each of the standard types of hoist manufactured. A number of pages is devoted to illustrations of industrial hoist applications.

Gifford-Wood Company, Hudson, N. Y.—Bulletin 74 illustrates and describes the Gifford-Wood electric capstan car puller which makes a one-man job of "car spotting" in industrial plants.

The Falk Corporation, Milwaukee, Wis.—Bulletin 31 describes the Falk herringbone gears. Among the subjects taken up are the advantages, the application, material, types, design, gear cutting and special gear data with special instructions for ordering gears. Bulletin 32 gives similar information on Falk herringbone gear units for speed reduction.

American Engineering Company, Philadelphia, Pa.—A small folder describes the "Lo-Hed" monorail electric hoist which is built in capacities of 1,000 to 12,000 lb. The special feature of this hoist is in the low head room required, as the construction is such that the hoist hook will come to within 14 in. of the I-beam on the 3-ton hoist. This gives a higher lift which enables higher piling or storing and so economizes on storage space. It can also be installed advantageously in shops with low ceilings.

Automatic and Electric Furnaces, Ltd., 173-175 Farringdon Road, London, England, E. C. 1—A circular describes the Wild-Barfield stainless steel hardening equipment, an electric furnace especially designed to take care of stainless (high chrome) steel cutlery.

The Brookins Manufacturing Company, Dayton, Ohio—A folder describes the Brookins "Eclipse" gasoline blow torch which is made in three sizes—to hold a half-pint, a pint or a quart. A special feature of this torch is that it requires no pumping, as it generates its own pressure.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Leaflet 20,005 describes the Type OD Safety-First Fuse Box, which is designed for use on circuits carrying up to 100 amp. at voltages up to 7,500 volts, for protecting outdoor distributing transformers.

Condit Electrical Manufacturing Company, South Boston, Mass.—Bulletin 417-2 entitled "Condit Protective Relays and Accessories for Electrically-Operated Switchgear," includes a general description of each type of relay, with dimensions, with the contact arrangements, adjustments, construction and other special features connected with it. Some of the relays included are inverse definite-time-limit overload relays for switchboards, instantaneous overload relays for switchboards, inverse-time-limit overload relays for industrial use (series type), overload relays of series and through types and reverse power relays of series and through types. Among the accessories for electrically-operated switchgears are control switches with indicating lamp, instantaneous control relays, hesitating control relays, lockout or trip-free relays and under-voltage relays.

Link-Belt Company, 910 South Michigan Avenue, Chicago, Ill.—Book 480 entitled "Electric Hoists and Overhead Cranes" is not only profusely illustrated with photographs of actual installations of some of the more recent Link-Belt electric hoist installations, but has many line and wash drawings. In addition the subject of proper installation and efficient operation is fully covered with a wide variety of practices and methods employed by users in widely divergent fields.

Pennsylvania Flexible Metallic Tubing Company, 201 North Broad Street, Philadelphia, Pa.—Bulletin 55C describes the "Penflex" all-metal, heavy duty hose and coupling for tank car unloading.

The Manheim Manufacturing and Belting Company, Manheim, Pa.—How "Veelos" Balata belting is made and many of the advantages claimed for it, together with transmission and other operating data, are given in a small folder.

Smooth-On Manufacturing Company, 570-574. Communipaw Avenue, Jersey City, N. J.—Illustrated catalog No. 9, "Smooth-On Instruction Book"

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shows when, where and how to use Smooth-On iron cement, paint and corrugated iron gaskets in making the numerous repairs necessary around industrial plants, in addition to listing a wide variety of uses together with a large number of illustrations and descriptions of actual repairs which have been made in a variety of industrial concerns.

Advance Electric Company, St. Louis, Mo.—Type WS single-phase, constant-speed motors, which are made in sizes from ⅛ to 7½ hp., are covered in Bulletin No. 16. Space is given to instructions for installation and care of the motor.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio—Bulletin 402 describes the Type TR universal thermal relay for controlling circuits not exceeding 6 amp. at 125 volts or 3 amp. at 250 volts. This relay was primarily designed for the protection of electric motors against overloading, overheating and roasting and the resultant destruction and failure of the insulation.

Mica Insulator Company, 68 Church Street, New York City—A catalog entitled "Electrical Insulating Materials" gives a revised price list and discount sheet of the wide variety of electrical insulation materials, such as mica in various forms, cloth, cement, tape, sleeving, silk and many other products.

Edison Lamp Works of General Electric Company, Harrison, N. J.—Bulletin LD 110A, entitled "The Lighting of Textile Mills," devotes over thirty pages to a discussion of this subject on information compiled by A. L. Powell of the Lighting Service Department. Among the subjects discussed are: Reflecting equipment, spacing of outlets and size of lamps, general lighting scheme, detail recommendations for various types of mills, and so on.

Quadrangle Manufacturing Company, 553 West Monroe Street, Chicago, Ill.—A catalog entitled "Quad Lighting Units" describes a variety of fixtures for commercial and industrial purposes. In addition several pages are devoted to the discussion of illumination and methods of calculating the intensities with examples showing the application of these methods. The various types of socket and shade-holder steel-porcelain reflectors for industrial plants are illustrated.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—An 8-page booklet, Special Publication 1667, contains a list of over 300 installations of Westinghouse industrial heating apparatus and gives a more definite idea of the extent to which electricity is being used for industrial heating purposes. A few of the industries making use of electric heat are: manufacturers of abrasives, airplane factories, bakeries, furniture factories, foundries, hospitals, railway companies, restaurants and cafeterias, rubber mills, steel mills, textile machinery manufacturers, textile mills, tool manufacturers, and wire mills.

The Packard Electric Company, Warren Ohio—A 16-page booklet entitled "Installation and Care of Transformers" discusses the general rules covering transformer installations under the following headings: Inspection, drying, connection, handling, oil, hangers, general engineering recommendations, polarity connections and diagrams. Particular emphasis is placed on instructions for transformer installation and their care in use.

General Electric Company, Schenectady, N. Y.—A 12-page "Index to Descriptive Bulletins and Sheets" lists the various bulletins and other literature issued by the Publication Bureau. Another 16-page booklet entitled "Index to Instruction Book and Cards" lists the various instruction books and cards provided for the different kinds of equipment.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Bulletin 6106 gives the features of design, dimensions, description, price and other features about direct-current automatic starters of the time-limit type with magnetic main contactors.

D. O. James Manufacturing Company, Chicago, Ill.—Bulletin 8 devotes over 100 pages to a discussion of the James spur and worm gear speed reducing transmissions and universal drives. A large number of illustrations shows this construction and the wide range of adaptability in service in many different lines of industry.

Sangamo Electric Company, Springfield, Ill.—Bulletin 61 gives instruction for the installation, use and operation of the Sangamo Type 8 single- and poly-phase watt-hour meters. A number of pages is devoted to diagrams and connections.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A special 4-page bulletin describes the Westinghouse-Frankel Solderless Connections, which are made up in various types for different special uses.

B. F. Sturtevant Company, Hyde Park, Boston, Mass.—An attractive 56-page bulletin, No. 311, covers the Type 12 steam turbine. Part I gives in detail the construction and many of the applications; Part II is devoted to the care and operation, with special emphasis on lubrication, bearings, adjustment; Part III shows dis-assembled views and cross sections with every part properly listed and numbered.

Schweitzer and Conrad, Inc., 4435 Ravenswood Avenue, Chicago, Ill.—A 12-page bulletin, No. 223, entitled "Indoor Bus Supports, Style C," gives, in addition to a discussion of the various types, the prices and dimensions.

The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio—Instruction Sheet 6 gives the wiring, mounting, potential adjustment, application and theory of operation, as well as diagram and part list for the Type F-2 relay which is used to control the operation of an automatic reclosing circuit breaker.

The Cowan Truck Company, Holyoke, Mass.—A group of five bulletins illustrate and describe various industrial applications of the Cowan hand lift trucks and skid system. For example, Bulletin 15 gives a general description of the hand truck in operation and its many economies. Bulletin 16 covers its use in facilitating manufacturing processes in machine shops and similar places. Bulletin 17 is on handling boxed, packaged, bottled and canned goods. Bulletin 18 is on handling bundled, rolled, sheet and bagged goods. Bulletin 20 describes the handling of lumber, furniture and similar loads.

Reliance Electric and Engineering Company, Ivanhoe Road, Cleveland, Ohio.—A 51-page reprint has been made of a paper entitled, "Anti-Friction Bearings in the Steel Mill," by A. M. MacCutcheon, chief engineer of this company, which was presented before the Association of Iron and Steel Electrical Engineers. This is of general interest and value to users and designers of machinery and power equipment in other industries.

The Arrow Electric Company, Hartford, Conn.—Catalog 20, on "Wiring Devices," devotes 160 pages to listing and illustrating the line of wiring devices. The condensed arrangement and grouping together of related devices and cross indexing has been planned for quick and easy reference.

Despatch Manufacturing Company, Minneapolis, Minn.—Catalog 4 devotes fifty-six pages to describing and illustrating electric ovens for annealing, armature and coil baking, temper drawing, drying, and a wide variety of other purposes.

Midwest Air Filters, Inc., 100 East Forty-Fifth Street, New York City—"Dust Problems and Their Solution," describes the applications of Northwest Air Filters in the solution of industrial dust problems such as high pressure and low pressure filters, compressor filters, paper and textile mills, in connection with heating and ventilating units, and in other applications.

Mitchell-Rand Manufacturing Company, 18 Vesey Street, New York City—Book 423, entitled, "Everything in Insulation," devotes 160 pages to a description of the different insulating materials, their uses and applications, as well as their insulating value. A number of valuable tables are included in the last ten pages. This is a handy book for reference.

Crescent Truck Company, Lebanon, Pa.—A group of loose-leaf folders in a binder describes the various types of Crescent electric industrial trucks and their applications. Among these are high wheeled, load carrying trucks for all around industrial service which are made in standard and short body for use on elevators. Tractors, low platform, and lift platform trucks are also described.

The Nichols-Lintern Company, 7960 Lorain Avenue, Cleveland, Ohio.—A folder, "It Takes Sand to Win," describes an electric sander which distributes sand on the runways of a traveling crane through the operation of hand or foot switch located in the operating cage.

Sumet Corporation, Ellicott Square, Buffalo, N. Y.—Three grades of Sumet babbitt for different industrial uses are described in a small folder.

The American Pulley Company, 4200 Wissahickon Avenue, Philadelphia, Pa.—A folder describes the American pressed steel hangers for line-shaft work.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

December, 1923

McGraw-Hill Co., Inc. Chicago. Ill.



Thoughts of the waning year bring to us a deep sense of obligation to those whose confidence we have tried to merit

We wish you a

Merry Christmas

and a

Happy New Year

Howell Electric Motors Company
Howell, Michigan

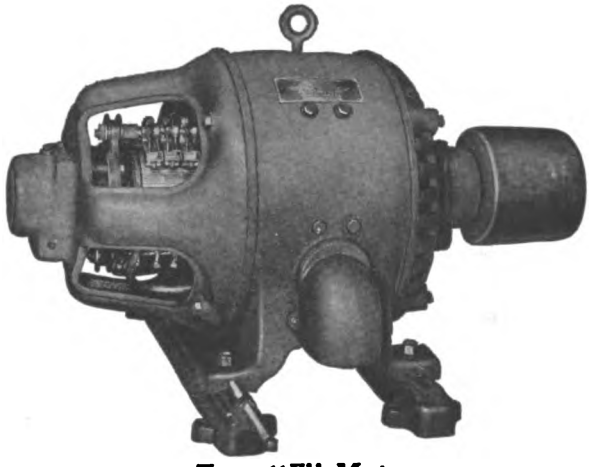
Howell RED BAND ELECTRIC Motors

Make Good On The Hard Jobs

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MOTORS

DIRECT AND ALTERNATING CURRENT

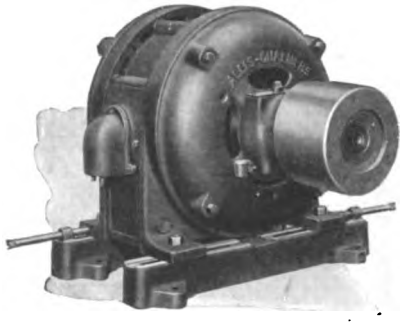


Type "E" Motor

Allis-Chalmers Induction Motors

Type "AR" Constant Speed

Type "ARY" Variable Speed of Correct Design and Rugged Construction



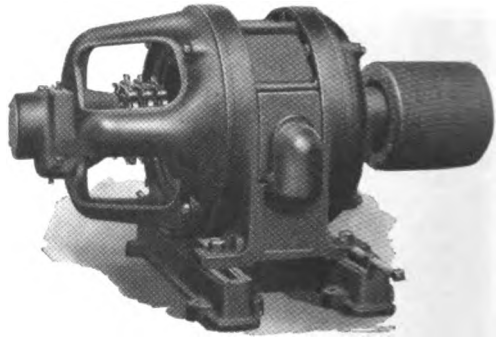
Type "AR" Motor

Allis-Chalmers Type "E" Direct Current Motors

Built for *Service.*

Constant or Adjustable Speed Ratings

For Belting or Direct Connection



Type "ARY" Motor

Send for Bulletins

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Electrical Machinery
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Flour and Saw Mill Machinery
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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 81 · Chicago, December, 1923 · *Number 12*

It's 25 Days 'Till Christmas

When the joys of youth and manhood intermingle in the giving that we do.

ON CHRISTMAS NIGHT in the section where I was born every member of the family hung up a stocking (Christmas trees were associated with church celebrations) and everybody wrote a letter to Santa Claus. Those who didn't write a letter talked about it so that the effect was the same and somehow from the many things suggested in letters or the ones talked about, everybody got something that they expected and really wanted and so they were happy on Christmas day. One of the things we always asked for and always got because it was an easy request to fill was plenty of nuts, raisins and candy—and as a boy I enjoyed these just as much as anything else I ever received at Christmas time.

Now I've hung up my stocking already and in the letter to Santa I have asked for something like the nuts, raisins and candy that brought gladness to my heart in those childhood days when the more expensive gifts did not mean much. This year I want a letter from every reader of INDUSTRIAL ENGINEER who has got something worth while out of the paper during the year, telling how he has used one practical article or two, or three, in some way to his own benefit in his work. Then I want, next, a suggestion for some new material or information that we have not published, but which you would like very much to get. Then I want you to end your letter with some little expression of good will or Merry Christmas message for the editors (Braymer, Van Brunt, Gooding and Hubert), who have done the best they know how to make you feel that they are working with you and for you in making INDUSTRIAL ENGINEER *your paper*. In a word, let's all of us get better acquainted in the spirit set down by that popular poet, Edgar A. Guest, in these lines:

When you get to know a fellow, know his joys and know his cares,
When you've come to understand him and the burdens that he bears,
When you've learned the fight he's making and the troubles in his way,
Then you find that he is different than you thought him yesterday.
You find his faults are trivial and there's not so much to blame
In the brother that you jeered at when you only knew his name.
When you get to know a fellow, know his every mood and whim,
You begin to find the texture of the splendid side of him;



You begin to understand him, and you cease to scoff and sneer,
For with understanding always prejudices disappear.
You begin to find his virtues and his faults you cease to tell,
For you seldom hate a fellow when you know him very well.

Don't forget the ending to your letter, for I want to pass on to the editors some little expression *from you* like you have so frequently addressed to me personally that will indicate that there truly is "Peace on Earth Among Men of Good Will at Christmas Time."

This much I really want and expect this year for Christmas just as I really wanted the nuts, raisins and candy of those good old days, gone but not forgotten. And to all of you I wish a million things—but above all, health, happiness and prosperity and a very Merry Christmas.

Practical Pete

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A Glimpse into the Works of the

Endicott-Johnson Corporation

Where skins and hides are tanned into leather, which is used to turn out 130,000 pairs of shoes daily. The twelfth of a series devoted to the growth and extent of our basic American industries

PERHAPS one of the best examples of factory specialization is found in the boot and shoe industry. Up until well along in the nineteenth century a shoemaker built the shoe or boot complete. It was not until the early part of the nineteenth century that shoes were even made right and left. Today shoe-making is a highly specialized factory industry where each worker does a single operation on a right or a left shoe only. The shoe passes on from operator to operator and machine to machine until completed. Some idea of the extent to which specialization has been carried out is shown by the fact that, depending upon the grade, style and quality, a shoe passes through from 175 to over 200 separate operations. Generally, each of these is performed by a different worker and on a separate and special machine. The invention and production of these special shoe machines alone has developed into an extensive business which has helped make possible the wide substitution of machinery for hand labor in this industry, as well as better and cheaper shoes.



The original plant from which the Endicott-Johnson Corporation has grown.

When this original factory was taken over in 1884 it had a daily capacity of 500 to 600 pairs of shoes. Today the entire organization can produce 130,000 pairs per day. This is now called Johnson City, N. Y., in honor of the present president.

The shoe industry was first established and still largely centers in New England and New York, where in some cases it is the principal industry of entire communities. In recent years additional manufacturing centers have been established in the Middle West, particularly around St. Louis, Chicago and Milwaukee.

One of the largest and most interesting of these eastern boot and shoe industrial communities centers around the plant of the Endicott-Johnson Corporation at the adjacent cities of Endicott and Johnson City, N. Y. About forty years ago H. D. Endicott, now deceased, a young leather dealer, took over the management of a creditor shoe factory employing about 500 workers in Leistershire, New York. Later the name of the city was changed to Johnson City. He chose one of his foremen, George F. Johnson, who is now president of the company, as superintendent.

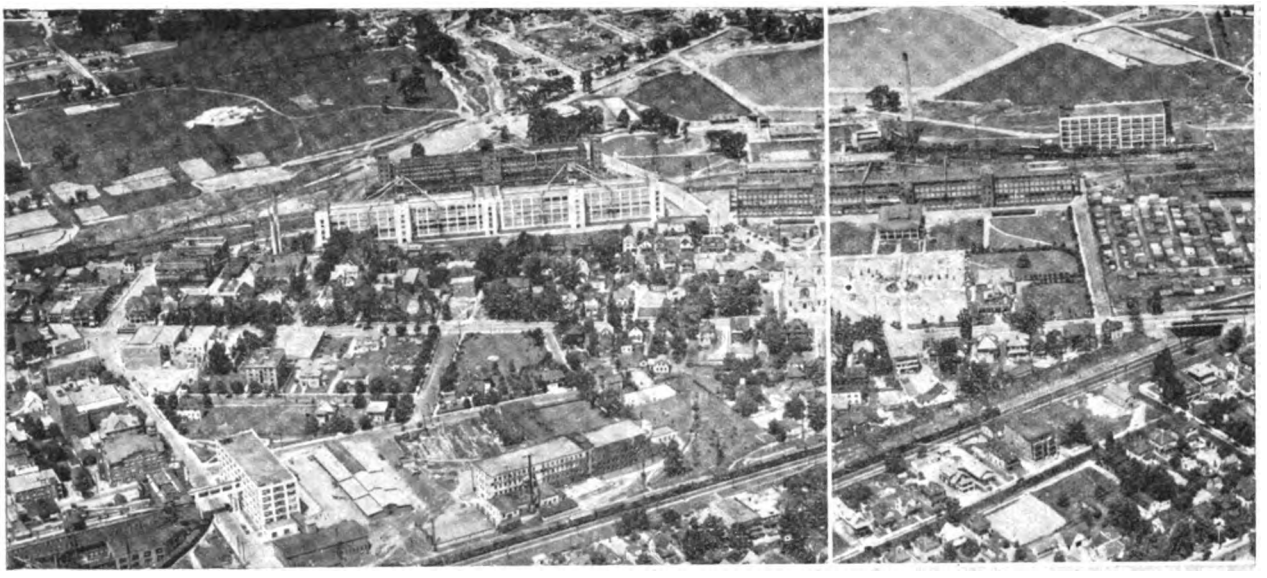
The business has grown from the small factory shown at the head of this article to be the largest producer of shoes in the world, occupying twelve factories and six tanneries, several of which are shown in the other accompanying illustrations. A good idea of the development of the industry is indicated by the increased output per worker during

A modern factory which replaced the original factory above.

This plant is known as the Corliss Avenue Work Shoe Factory and is the largest of the entire group. The plant has 14.10 acres of floor space, employs 1,400 people, and has a daily output of 26,400 pairs of shoes, or over 18 pairs of shoes per employee. The upper floors of the smaller white building at the right, the Utility Factory, are used for making children's shoes. Shoe cartons and other supplies are made in the lower floors.

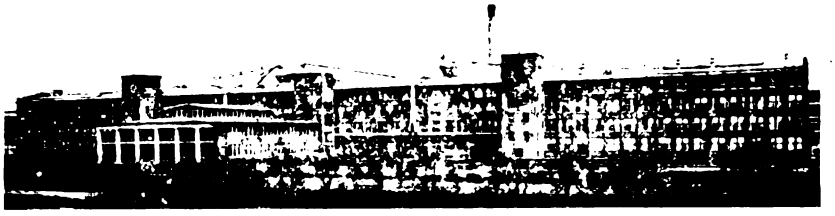


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An airplane view of some of the Endicott-Johnson factories in Johnson City, N. Y.

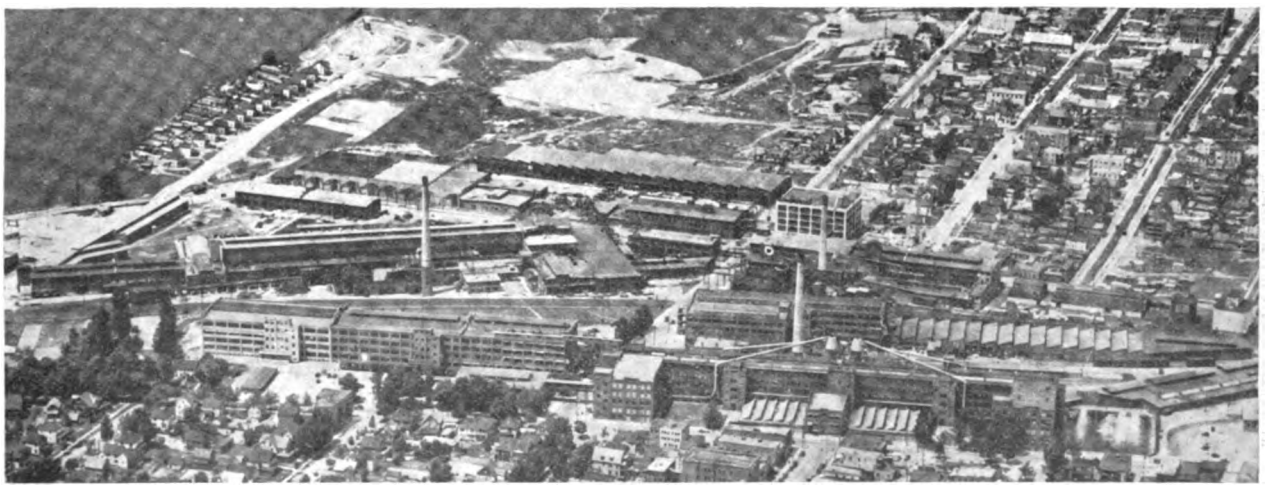
A portion of the Corliss Avenue shoe factory is shown in the lower left-hand corner of the above illustration. The long white building near the center of the illustration, the Victory shoe factory, is said to be the most modern and complete shoe factory in the world, with 2,000 employees, and a daily output of 19,000 pair of shoes. About 19,200 pairs of scout shoes are made daily in the building just back of the Victory shoe factory. The McKay factory, the long dark building at the upper right (another view is shown in the illustration at the right), produces 27,600 pairs of shoes per day, which is the largest output of any of the company's factories. The two-story building in front houses one of four restaurants which serve meals to the employees, at 15 cents each. The white concrete building in the upper right-hand corner makes scrap up into leather cutting block and leather flooring. These views show the parks, lakes, swimming pools, and other features which make the surroundings attractive to the workers.



that time. About forty years ago the 500 workers in the original plant could turn out approximately 500 pairs of shoes a day, or about a pair of shoes per employee. Today the 16,000 employees produce 130,000 pairs of shoes per day which, after eliminating the employes in the tanneries and similar departments, is over ten shoes per day per employee. The boot and shoe industry is the largest user of leather, and to supply these factories six tanneries which produce 20,500 sides of leather and skins per day are grouped around the shoe plants. Five of these tanneries are in Johnson City, N. Y. In addition to leather, 4,100 miles of thread and 14 tons of tacks and nails are used per day. The company also makes the shoe cartons in which each pair

An airplane view of the group of factories at Endicott, N. Y.

The Endicott-Johnson Corporation obtain their leather by tanning raw hides. This group of factories contains the largest single tannery in the world, which produces 6,200 sides of leather daily. Another tannery in this group is devoted to making fine-grade, calf skin upper leather. Altogether the six tanneries have a daily output of over 20,500 sides of leather. Another factory produces daily 22,800 pairs of mens' and boys' dress shoes. One of the buildings also houses the sales department, offices and shipping department, which distributes over thirteen carloads of shoes a day.



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Interior views of the sole cutting room and the cutting room of the welt factory.

Cutting the leather so as to give the least amount of waste is one of the important considerations in the boot and shoe industry. The welt is the strip of leather which is sewed around the lower edge of the upper of a shoe. The sole is sewed at its edges to this strip.

is packed and uses the scrap leather in making leather flooring and cutting blocks.

In addition to the large production of shoes the Endicott-Johnson Corporation is well known because of its liberal employee policies. For example, it was one of the first concerns to recognize the value of steady year-around production and employment instead of a few months of rush, overtime work, followed by periods of idleness. However, each employee gets two weeks' vacation annually with pay and also shares in the profits of the company. Much attention is paid to housing problems and to making the city attractive to the workers by parks, play grounds, and other features. Four company restaurants serve employees meals at 15 cents each.

The entire leather industry of the United States, according to the manufacturers census of 1921, is not large and, including those connected with the tanning of hides and skins, employs only 280,000 wage earners. Of these 49,000 are employed in tanning and 183,500 in the manufacture of boots and shoes, with the remainder engaged in the production of belting, harness, gloves and miscellaneous leather products. In 1921, according to the latest manufacturing census report, the tanneries of the United States produced leather worth $383,000,000. Much of this went into the production of boots and shoes valued at $867,500,000. The total value of all finished leather products was $1,160,820,000. As the boot and shoe industry requires considerable hand labor in production, the cost of materials represents about 60 per cent of the value of the finished product. In the tanning industry, on the other hand, the cost of the raw material represents a much higher percentage, as less labor is expended. Tanning is a process which requires some months and ties up the capital invested during that time. The raw hides are a by-product of the meat-packing industry. Many, however, are imported from other countries.

Three interior views of a shoe factory.

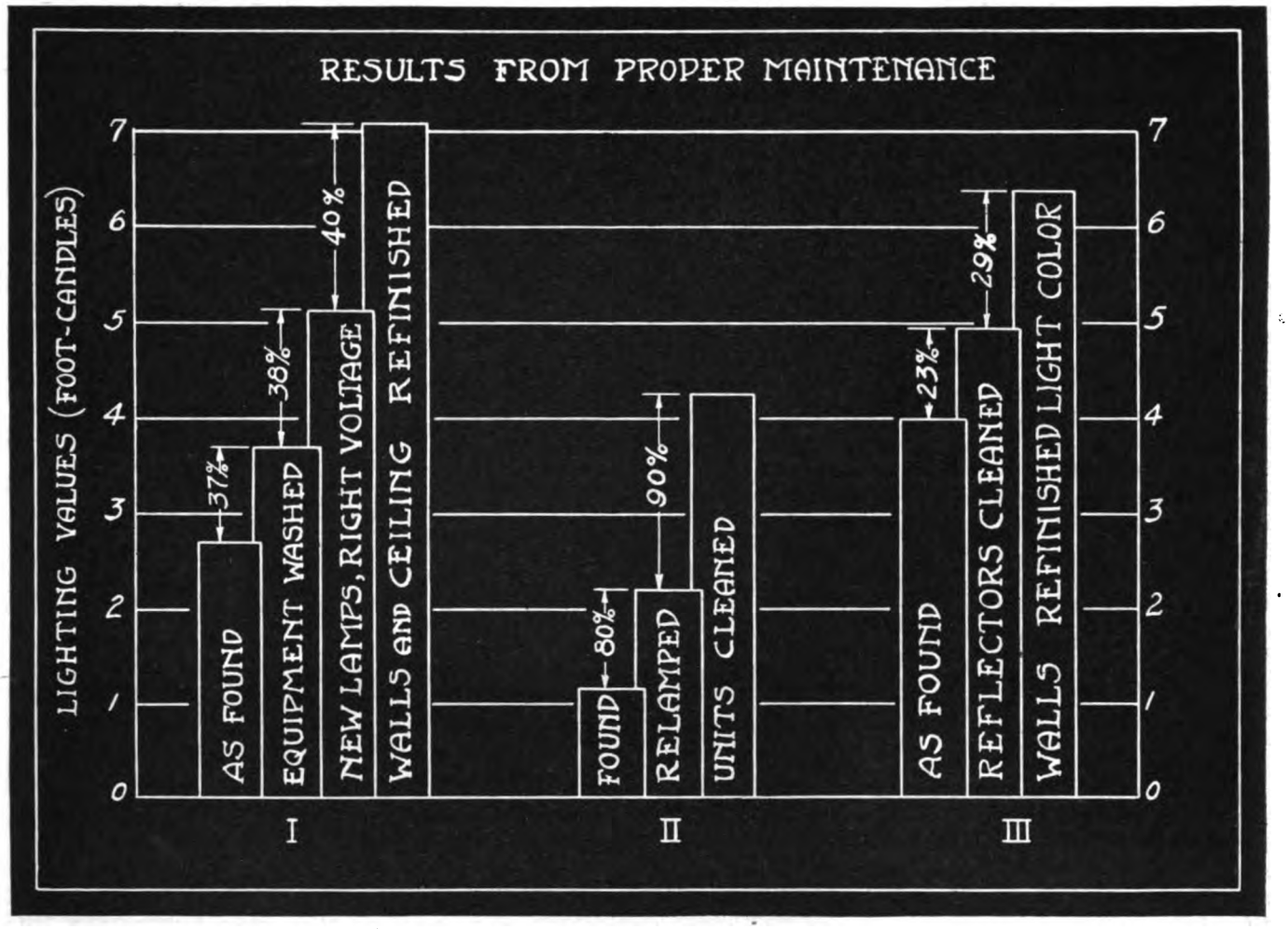
In the stitching department at the right, the pieces of leather which form the "upper" of the shoe are stitched together. In making the daily output of 130,000 pairs of shoes, 4,100 miles of thread are used by the Endicott-Johnson Corporation. In the "lasting" room, at the left below, the uppers of the shoes are shaped over a last and the soles put on. In addition to the thread for sewing on these soles, 14 tons of tacks and nails are used daily. After finishing and inspecting, each pair of shoes is placed in a paper carton. The view below shows the carton-making department. The manufacture of shoes is one of the most highly specialized industries. Making a shoe requires about 200 separate operations made on special machines.







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How One Factory Has Benefited by

Revamping an Obsolete Lighting System

And Installing the Proper Lamps and Reflectors to Give Better Distribution and Higher Intensity of Light

THE ACCOMPANYING illustrations show the transformation resulting from replacing drop cord lighting with bare lamps by large gas-filled lamps in efficient reflectors. These units were spaced as shown in Fig. 5 to give proper direction of light and eliminate dark spots and shadows around machines, which are accident hazards in a factory. The number of lighting units was reduced from 65 to 51 but the watts per sq. ft. increased from 0.6 to 1.0, with an increase of the total wattage of lamps installed from 3,250 to 6,075 watts.

By J. J. McLAUGHLIN

Illumination Bureau, Westinghouse Lamp Company

IN going back of the Stone Age, we find that men of that period knew of no light at night except that of the moon and stars, or the blinding flash that broke with a crash from the clouds. When the cave man arose, however, and learned the art of producing fire, he also discovered that it gave light; therefore, the light thus produced made the cave a very haven of refuge from the darkness and unseen terrors of the night outside.

Gradually there came about the torch made of pine knots found in refuse from decaying logs. These small knots, dried and split and fastened in a bundle, burned with a brilliant if smoky light and served to drive away wild beasts, as well as to point out the pathway to and from the cave.

Next came the hunter roasting his game in the fire. He noticed that the fat which dripped into the flame burned vigorously, giving out a great deal of heat and light; so, collecting some drippings in a shell or hollow stone he set it on fire and saw that it would burn of itself and by adding a wick of shredded bark he made the first lamp.

The lamps and candles which

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sprang from such simple beginnings were the only form of artificial light for illumination for many centuries. But the necessity for some form of artificial illumination has urged man to develop many kinds of illuminants. Coincident with the invention of the candle there was a greater development of the lamp, because here was an opportunity for an illuminant of a more permanent character. When a candle burns, the candle itself is consumed, but when a lamp burns, it is only the oil in the lamp that is lost. The lamp itself remains. As lamps became larger they gave off more light, but for thousands of years there was no source of artificial illumination that could compare in brilliancy with the sources of today.

The discovery of petroleum in the United States during the middle of the last century and the great supply of "rock-oil" was the beginning of an industry that has covered all parts of the inhabited earth with products that have been used to a great extent as sources of illumination. However, the coming of, and the development in, the use of gas and electricity as sources of artificial illumination, has brought about a change in controllable illumination for the workshop as well as for the home and the social life of the individual.

In the past, when the individual worked at his trade or business, alone, in a corner of a small room or shop of his own, the requirements of illumination called for only the individual source hung close to the work. The small light sources and equipment available in those days would permit the use of only such a method of lighting.

While in these days this method of using the local lighting unit directly over and close to the work is ideal and must be used where the work is fine or exacting, nevertheless, with the development of machinery and the collecting of a number of workmen in one room or shop, bringing about mass production, there has been brought about a need for greater improvement in the lighting of the workshop. The development of larger incandescent lamps has followed this need.

Such an improvement was recently made in one section of the C. T. Williamson Wire Novelty Co.'s plant, located in Newark, New Jersey. In Fig. 1 is shown the old method of suspending bare lamps (small sizes) on drop cords, with no reflectors over the lamps to shield the eyes of the workman. A large portion of the light was permitted to go off in a horizontal direction, whereas a good and properly designed reflector would direct a large percentage of the light on the work and where needed.

This method of bare drop cord lighting has become obsolete and is being replaced by modern and efficient use of large gas-filled Mazda lamps, equipped with efficient types of reflectors. The complete units are spaced and mounted in proper positions so that the workmen will obtain a goodly amount of properly directed light on his work, while at the same time the surroundings are illuminated sufficiently to eliminate darkness and annoying shadows, which are accident hazards in the factory.

Fig. 2 shows the same work bench section as in Fig. 1. Here the improvement over the old drop cord lighting is plainly evident. The former system over the bench consisted of 50-watt Mazda B lamps, bare, suspended on long adjustable drop cords, with key sockets. Most of the working hours these lamps were kept in a low position directly in front of the eyes, thus causing a harmful glare which in time became seriously annoying to the workman. This method also had the disadvantage that the lamp was in the way and the workman lost time in adjusting it to some other position or height. Also, unless the lamps had wire guards to protect them they were often broken, resulting in lost time for the work-

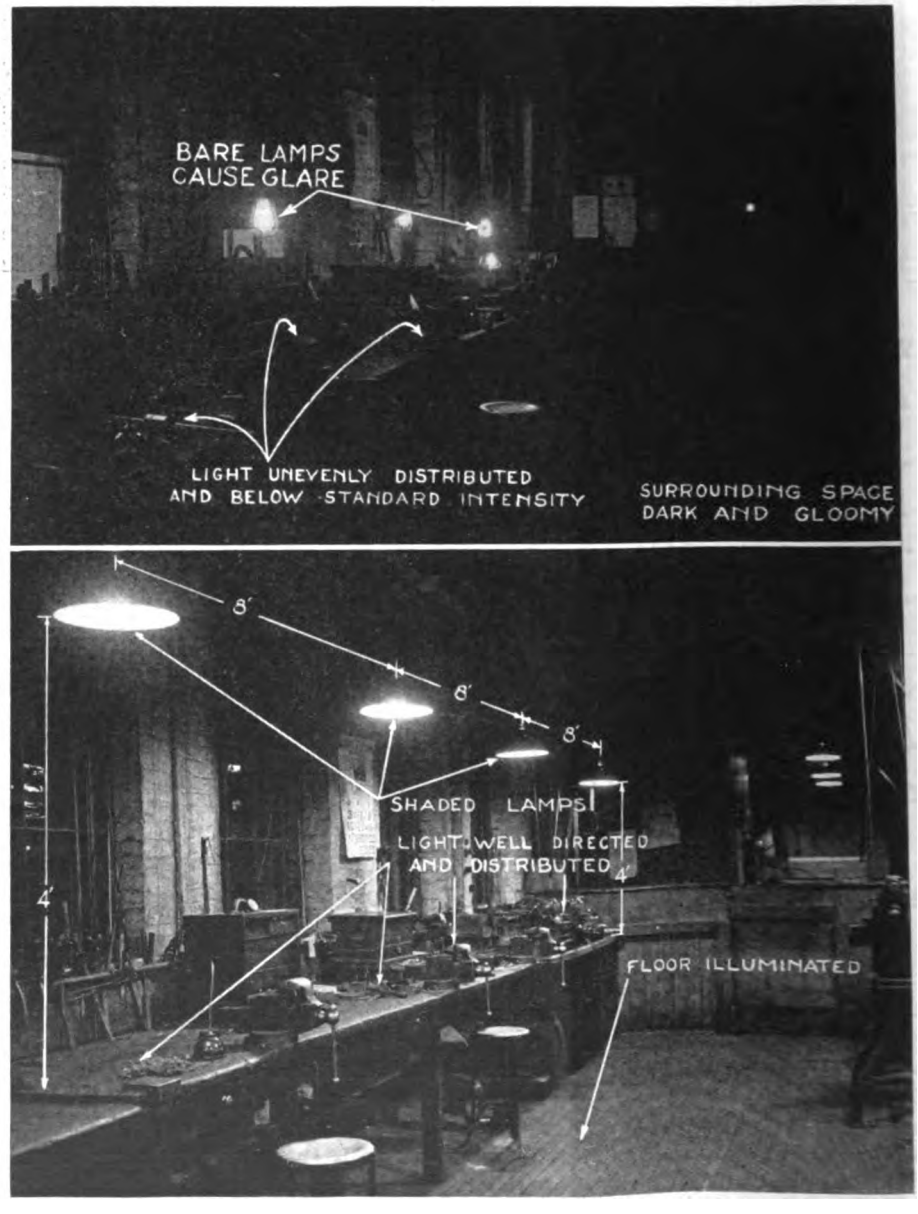


Fig. 1 (Above)—The old local lighting over benches consisted of 50-watt bare lamps on drop cords. Fig. 2 (Below)—New lighting installation replacing that shown in Fig. 1, using 75-watt, Westinghouse Mazda, gas-filled lamps and standard dome, R. L. M. reflectors.

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man while without the light, plus the cost of replacing the lamp.

The new installation, as in Fig. 2, shows the lamps at a fixed height of 4 ft. above the top of the bench and spaced on symmetrical centers 8 ft. apart over the outer edge of the bench, thus giving a uniform illumination over the whole working area and the immediate surrounding space. The unit consists of 75-watt, Westinghouse gas-filled Mazda white lamps and Westinghouse standard-R. L. M., porcelain-enameled, steel reflectors.

The same size of lamp and style of reflector is used over other benches in various parts of the room, the location and arrangement of which is shown in the plan of Fig. 5. The method of lighting as illustrated in Fig. 2 is called localized-general lighting. By locating the units over the working positions of the benches and machines, at the same time keeping them well above the workman's head and spaced in a symmetrical manner, there is provided a combination of local and general overhead lighting, with the good features of each system.

While efficient results can be obtained by localized-general lighting, if properly installed, there are, nevertheless, cases of very fine work in the shop when it is necessary to use a lamp close to the work. In such cases, several factors should be considered; namely, the size of the lamp, the type of reflector, the method of mounting same, and the location. Fig. 6 illustrates in a graphic way an efficient and satisfactory method of installing this type of strictly local lighting unit. The upright supporting arm should be fastened near the back edge of bench so as not to interfere with setting work or tools on the bench, and working at a vise.

The bracket holding the socket, lamp and reflector, should be adjustable to permit moving the light to any desired position. The position shown in the figure permits the reflector (which may be smaller than shown, but never flat or shallow) to direct the light on the work, at the same time shielding the workman's eyes.

Supplementing the work benches along the walls, in the Williamson plant, the room is occupied mostly by automatic machines. In Fig. 3 is shown a general view of the room from one end. This view was taken under the old lighting system; the *lamps*, one may observe, can be seen very readily; however, this can not be said of the *machines*. The lighting units were similar to the old ones over the benches, consisting of 50-watt, bare lamps suspended on drop cords and hanging very low, many were only about three or four feet above the floor; thus from any part of the room glare from the bare lamps was prevalent. The lamps were located in a non-uniform manner, which gave bright spots in some sections and dark areas in others.

The view in Fig. 4 shows the new lighting system consisting of 150-watt, Westinghouse gas-filled, Mazda lamps, bowl-enameled, with Westinghouse standard-R. L. M., porcelain-enameled, steel reflectors. One unit is located in the center of each small bay of 10 by 16 ft. and is mounted 9 ft., 6 in. above the floor. This arrangement of units brought each row over the center of the machine rows, thus directing a large portion of the light on the machines, at the same time illuminating the balance of the floor space well, which can be noted by comparing Figs. 3 and 4.

In the new installation there is a total of fifty-one units as against sixty-five in the old, a saving of f o u r t e e n units to be maintained. While this advantage in the number of units was gained through an effi-

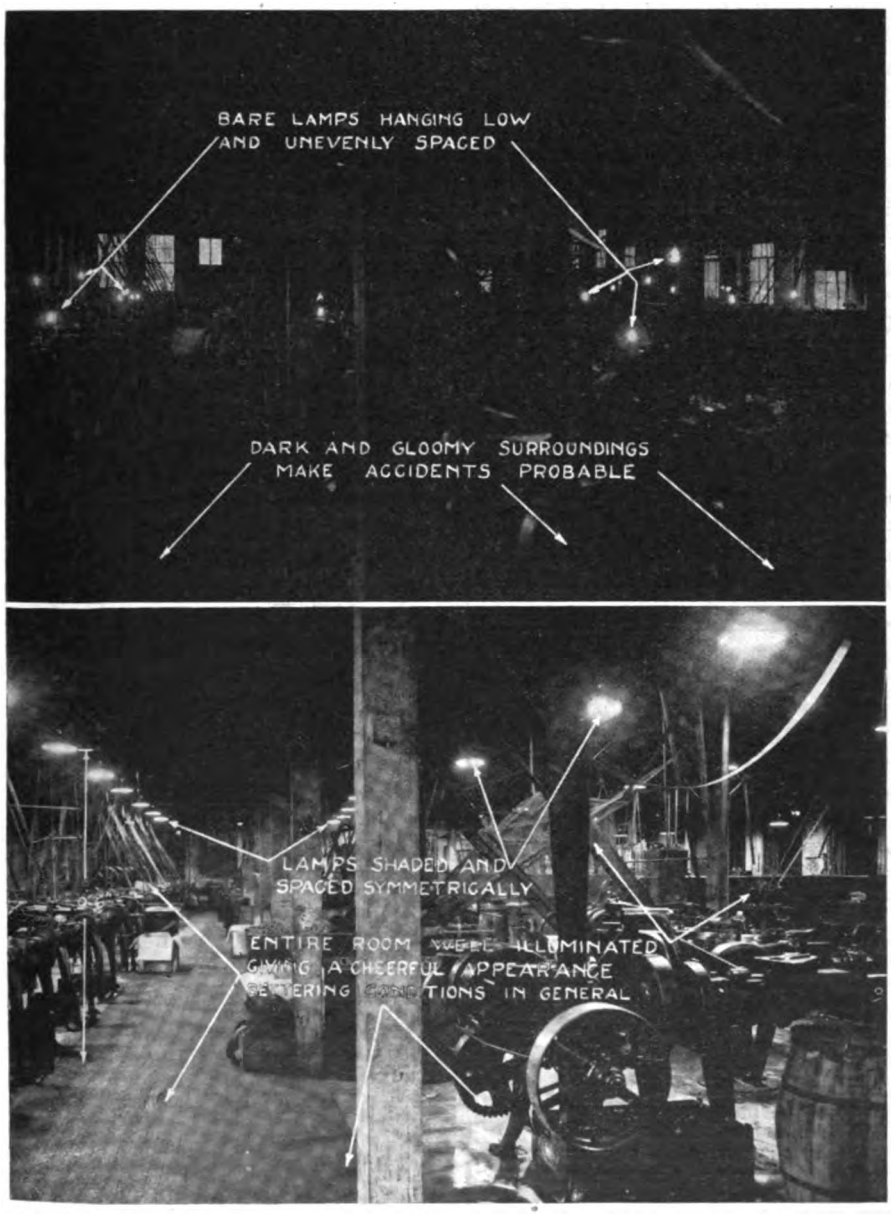


Fig. 3 (Above)—A general view of the shop showing the old lighting units consisting of 50-watt, bare lamps suspended on drop cords at various heights and spacings.

Fig. 4 (Below)—A general view of the shop after the new lighting system was installed, replacing the old system shown in Fig. 3. The new system consists of 150-watt, Westinghouse Mazda, gas-filled lamps, bowl-enameled and standard R. L. M. reflectors.

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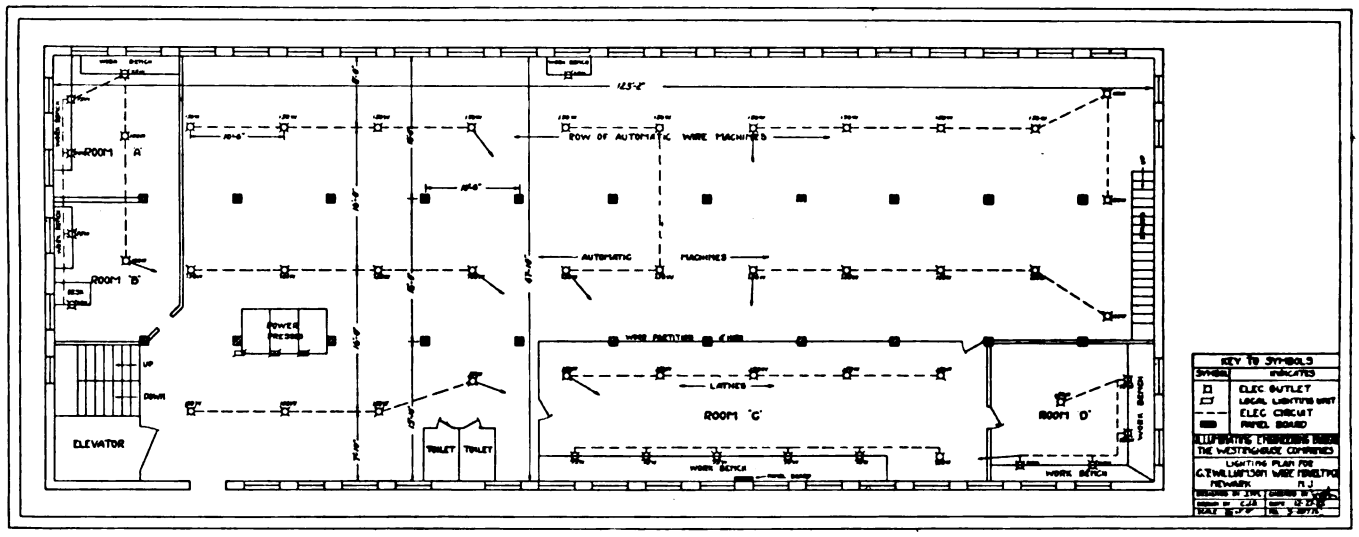


Fig. 5—Floor plan showing new layout of outlets, circuits, and location of control panel board in the C. T. Williamson Company factory.

cient arrangement of the outlets, the average watts per square foot of floor area was increased in the new installation. However, the intensity of illumination increased in a much greater proportion through the use of more efficient lamps and reflectors, and the results and advantages are evident.

In the old installation the sixty-five 50-watt Mazda B lamps represented a total of 3,250 watts or an average for the total floor area of 0.6 watts per square foot. In the new installation using fifty-one lamps in sizes of 75, 100 and 150-watts, the total wattage is 6,075, or an average of 1.0 watt per square foot.

The intensity of light directly under the 50-watt lamps of the old installation was about 20 to 25 foot-candles, but with irregular spacing and the lamps hung low, the intensity at various points between the lamps would drop down as low as 1.0 foot-candle. The main difficulty with the old installation was not that there was an insufficient amount of light on the working plane close to the lamp but it was due to the fact that the lamps were not shaded, were hung low and there was a great amount of glare in the eyes of the workmen, thus reducing their visual acuity and at the same time a large amount of light was going off in other directions than to the working plane. A large portion of the useful light was, therefore, lost, bringing about a low efficiency for the entire system.

In the new installation with the 150-watt lamps, the average intensity was about 8 foot-candles over the working plane. But immediately under the lamps, which in many cases were directly over the machines, an intensity of 14 foot-candles was obtained. In the case of the 75-watt lamps over work benches there was an average intensity of about 15 foot-candles.

In general the advantage that the new system has over the old system is that it provides a fairly uniform illumination over the entire room area, eliminating dark shadows and making it possible to get approximately the same appearance that a daylight lighted room would have.

While the advisability of good natural and artificial illumination is so reasonable that a list of its effects may seem commonplace, these effects are of such importance in their relation to factory operation that they are worthy of careful attention. The effects of good illumination, both natural and artificial, and the influences of bright and cheerful interior surroundings include the following:

1—Reduction of accidents.
2—Greater accuracy in workmanship, resulting in improved quality of goods.
3—Increased production for the same labor cost.
4—Less eye strain.
5—Greater contentment of the workmen.
6—More order and neatness in the plant.
7—Supervision of men made easier.

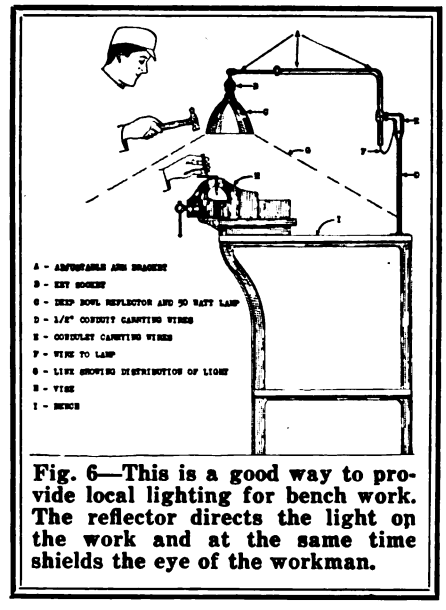


Fig. 6—This is a good way to provide local lighting for bench work. The reflector directs the light on the work and at the same time shields the eye of the workman.

While it is difficult to place a definite value on the savings effected in increased production and improved quality by good illumination, it by no means follows that such savings are insignificant or not substantial. The factory owner who ignores them neglects his own interests. Other items in the foregoing list, such as labor turnover, morale, or insurance rates are even more difficult to evaluate, but they are nevertheless real.

Lamps and reflectors should be inspected and maintained regularly, wiped off at least once every two weeks and thoroughly washed once every month. Clean warm water containing ammonia (about half a cup of commercial ammonia to a pail of water) will be sufficient.

In case of equipment that has been neglected for a considerable time, it is advisable first to wipe off the lamps and reflectors with a dry rag and then wash them with warm soapy water and dry them in order to remove the soap film, which would readily collect a fresh coat of dust.

The practical results obtained by sensible attention to lighting equipment are shown in the first diagram. These data emphasize the importance of inspecting and maintaining a lighting system in its state of maximum efficiency.

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THIS IS THE FOURTH of a series of articles by Mr. Martindale started in the October, 1922, issue. The first article dealt with troubles arising from the wrong grade of brush; the second which appeared in the December, 1922, issue, took up troubles due to faulty brush operation, and the third, in the March, 1923, issue analyzed defects in a commutator. The next and final article will discuss causes and effects of troubles arising from sources external to the armature.

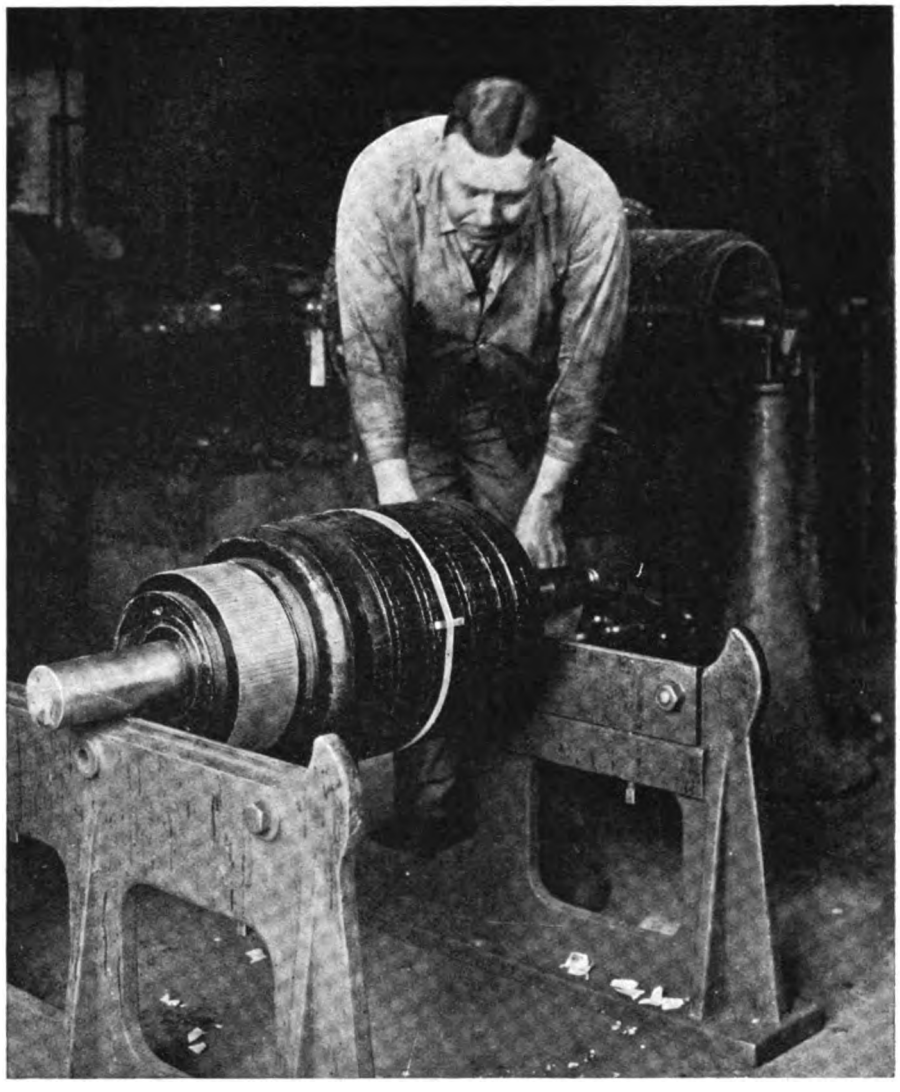
Some Troubles Caused by

Armature and Field Defects

That Appear at the Brushes and Ways in Which They Can be Corrected

By E. H. MARTINDALE

President, The Martindale Electric Co., Cleveland, Ohio



This illustration shows a simple method of balancing an armature on ways and then applying weights to the light side. This method may be used satisfactorily for all except high-speed armatures.

THIS ARTICLE follows the outline of Section IV of the double-page chart showing brush and commutator troubles that appeared with the first article of this series by the writer on pages 476 and 477 of the October, 1922, issue of INDUSTRIAL ENGINEER. In drawing up that chart, two armature troubles in Section IV were overlooked, namely: (*a*) Short circuits in armature coils. (*b*) Grounded armature coils or commutator bars. The equipment and methods used to locate these defects are similar to those for troubles Nos. 1 and 2 in Section IV and will be discussed as subheadings under trouble No. 2.

(*1*) *Loose End Connections and* (*2*) *Open Circuits in Armature Coils.*—An open circuit in an armature coil produces vicious sparking when the commutator bars connecting the ends of the coil pass under a brush. In a machine operating at over 900 revolutions per minute the sparking will appear continuous. The mica will nearly always be found badly pitted between the bars connecting the ends of the defective coils. The trouble can be temporarily repaired by soldering the end connections or commutator risers together. In a lap-wound machine the defective coil can be readily located by the pitted mica between the commutator bars. In a wave-wound machine, however, the pitting occurs at two points and if the open connection is bridged over, great care should be taken to avoid short-circuiting a good coil.

A poor connection between the end of a coil and the commutator riser will produce the same sparking at the brushes and pitting of the mica but in a less degree, depending on how defective the contact is. When located, the defective connection should be carefully cleaned and resoldered.

2a. Short Circuit in Armature Coils.—A short circuit in a coil, a short circuit between two coils, or a ground between a coil and the armature core will result in excessive heating of that portion of the armature. A ground between a commutator bar and the clamping rings will result in excessive heating of that part of the commutator as well as the portion of the armature connected to the grounded commutator bars. Usually these troubles will be accompanied by poor commutation.

The diagrams shown as Figs. 1 and 2 illustrate the means of locating open circuits, high-resistance end connections, short circuits and grounds. Fig. 1 illustrates a lap-wound armature. Current from a battery should be passed through the armature by brushes *B B* and a bar-to-bar test made with a telephone receiver, as shown at *A*. If the armature is in good condition, the click in the receiver will be the same between each pair of bars. If the click between any pair is less than

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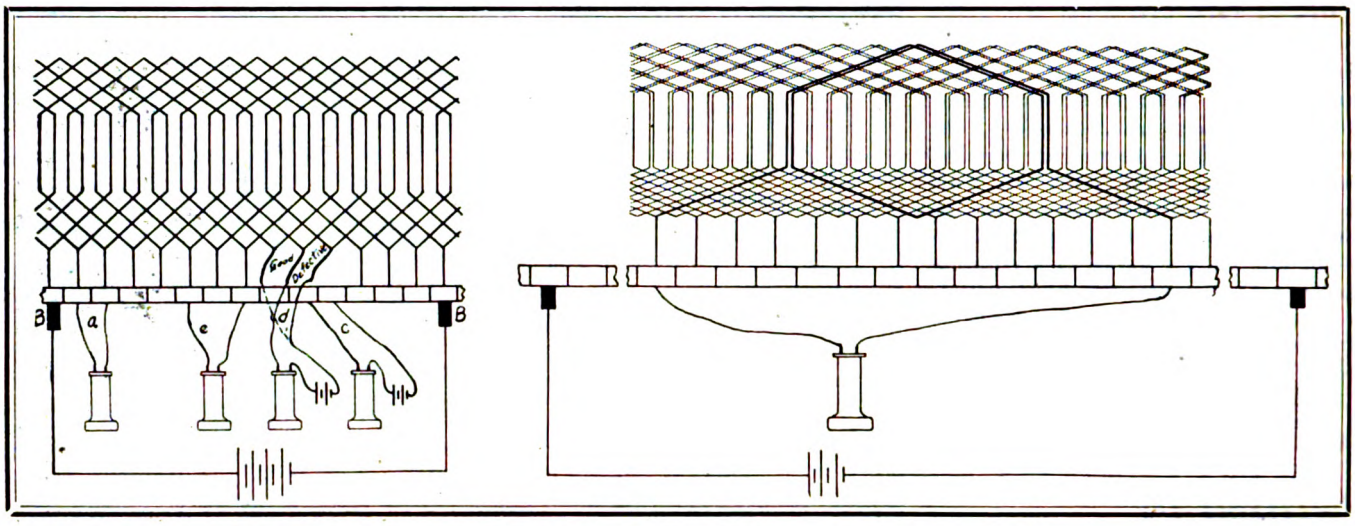


Fig. 1—Scheme for testing for coil troubles on a lap-wound armature.

Fig. 2—Scheme for testing for coil troubles on a wave-wound armature with two turns per coil.

normal there is a short circuit between two or more turns of the coil or between the commutator bars or risers. Examine carefully the commutator-bar risers to see that they do not touch each other or that no conducting material has gathered between them, and if they are found clear the end connections of the defective coil should be unsoldered and a test made between the commutator bars, as shown at *C*, with the battery in series with the telephone receiver. If a click is heard the short circuit is in the commutator, while if none is heard it is in the coil. On the bar-to-bar test if the click between any pair of bars is greater than normal there is an open circuit or a high-resistance connection. To determine whether trouble lies in the coil or the end connections, the latter should be unsoldered on the defective coil and on a good coil for comparison. The telephone test should be made as shown at *D* in Fig. 1. If the click is the same in the opened coils, the trouble is in the end connection. If no click at all is heard in the defective coil, or if the click is weaker in the defective coil than in the good coil, the trouble is in the coil and it must be replaced.

The number of coils per slot is equal to the number of commutator bars divided by the number of armature slots. If all individual coils are found correct and if there is more than one coil per slot, the first test should be repeated, spanning an extra commutator bar as shown at *E* in Fig. 1. This will locate any short circuits between two coils in the same slot as the click will be less when bridging the short.

In Fig. 2 a wave-wound armature is shown. Current should be passed through the armature as in the previous tests. Blue prints should be obtained from the manufacturer or the windings traced to determine the number of bars between adjacent brush studs of the same polarity and to determine whether the winding is progressive or retrogressive. In the usual "simplex" wave windings the number of bars will be found to be one more or less than an even multiple of the number of poles. If the number is one more the winding is progressive, and if one less it is retrogressive. In a progressive winding if we trace the connection once around the armature we arrive at the commutator bar ahead of the one from which we started. In a retrogressive winding we arrive at the bar behind the one from which we started. There are also some wave-wound machines where tracing once around the armature will bring us

Fig. 3—A milli-voltmeter provides another method of testing an armature for short circuits between coils.



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to two bars ahead or behind the starting point. This is called a duplex winding.

In Fig. 2 is shown the method of locating short circuits, open circuits and high-resistance connections in a wave-wound armature.

Current should be passed through the armature from a small battery at one positive and one negative brush on the opposite side of the commutator from where the tests are being conducted, all other brushes being removed.

The terminals of the telephone receiver should touch the bars connected to the opposite ends of the coil as shown in Fig. 2. After the proper spacing has been determined a string may be tied between the two terminals to keep the spacing correct. The test should be conducted clear around the armature. As in Fig. 1 a loud click will denote a high-resistance connection or an open circuit. If there is an open circuit, it is probable that no click will be heard until the telephone receiver bridges the defective coil. As in *D*, Fig. 1, the coil should be opened to determine whether the trouble is in the coil or in the end connections.

If the click is less at any point there is a short circuit in the coil. The test for a short circuit between two coils in a wave winding will depend on the nature of the winding. If it is a "simplex progressive" the spacing between terminals should be one less than in the above test. If it is a "simplex retrogressive" the spacing should be one more. If it is a "duplex progressive" the spacing should be two less bars, and if "duplex retrogressive" it should be two more bars. A click less than normal will locate the short.

To test for short circuits between commutator bars, the bar-to-bar test should be used as in Fig. 1.

2b. Grounded Armature Coils or Commutator Bars.—To test for a ground, all brushes should be removed. The telephone receiver should be connected from the armature shaft to the commutator bars with the battery in series.

Usually a grounded armature will cause excessive heating of both the commutator and the armature coils connected to the defective bar. After the ground has been approximately located the nearby end connections should be unsoldered and the test repeated to determine whether the ground is in the commutator or in a coil and, if the latter, in which coil.

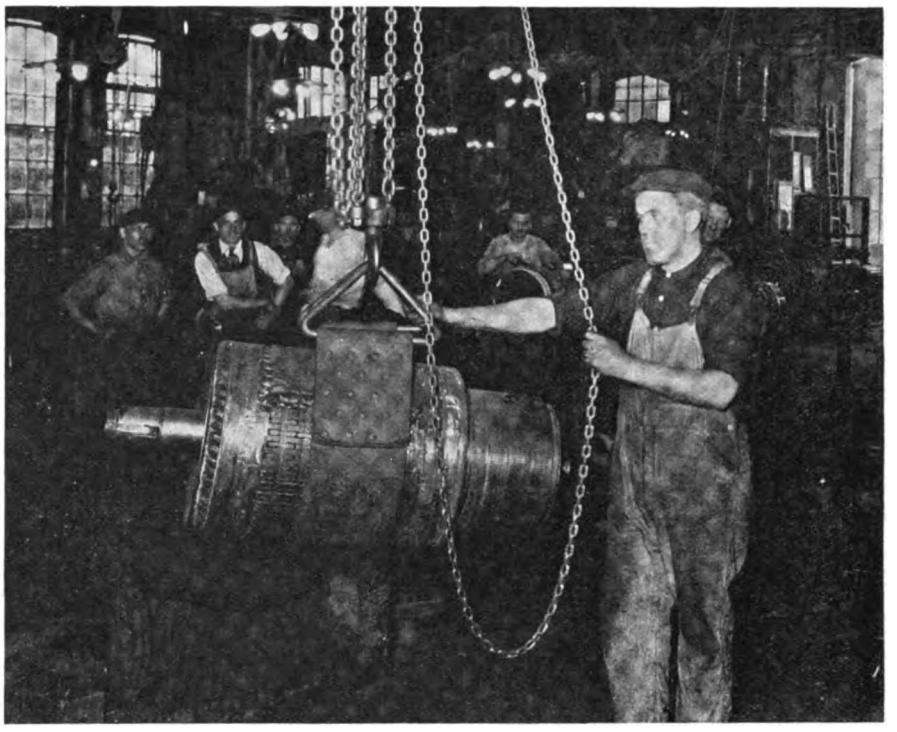


Fig. 4—Handling armatures in a sling made from belting lessens the chances of burring laminations. Jamming the edges of laminations so that they make electrical contact with each other promotes the flow of eddy currents and may be the unexpected source of heating.

If the armature is wave-wound and the commutator bars are free from grounds, care should be taken to unsolder the connection at both ends of the coils before trying to locate the exact coil.

3. Unbalanced Armature Winding.—By an unbalanced armature winding is meant one which does not have a theoretically perfect layout of coils or end connections. Practical details of such windings and the points to be considered were given by A. C. Roe under the heading "Laying Out Unequal Groupings of Coils" in the May, 1923, issue of INDUSTRIAL ENGINEER, pages 241 to 250.

4. Mechanically Unbalanced Armature.—If an armature is mechanically unbalanced it will set up vibrations when operating at full speed. On high-speed machines the vibration may be sufficient to throw the brushes from the commutator, resulting in sparking and flat spots and may even chip or break the brushes. The armature should be placed on parallel bars or balancing ways and sufficient weight added at the lightest point to balance it properly.

5. Jammed Armature Laminations.—Very little has been written on this important subject and it is doubtful whether its seriousness is generally appreciated. Armature cores are made up of a large number of thin iron stampings called laminations. The object of this construction is to produce a relatively high resistance in the iron core to prevent heavy eddy currents caused by the transformer action of the current in the coils which reverse direction at every pole.

Rolling the armature across the floor or other rough handling may jam the edges of the laminations and make the armature almost like solid iron. Similarly, turning an armature in a lathe will usually burr the iron enough to run the laminations together. The writer knows of one case where an armature burned out by grounding every two or three weeks and the reason could not be located. Finally the armature winder remarked that it was always the same coil. Extra care was taken in insulating this coil, but the trouble occurred again with the same regularity. The chief electrician then dismantled the armature, removed all the laminations, filed the burrs from the edges, re-assembled the armature and the motor ran for two years without another burn-out.

Another chief electrician of a large plant considered the care of armatures so important that he called all of his men in to watch him burr over the edges of the laminations along just one armature tooth with a light ball hammer.

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Then he passed alternating current through the armature equal to full load current and in less than an hour that tooth was a dull red and had charred the insulation on the adjacent coils.

If you have repeated burn-outs mark the armature so that you can determine whether it is always the same coil and, if so, it is probably caused by burred laminations. An armature should be handled with as much care as a watch.

6. Partial Short in Shunt Field.—If the shunt fields are in parallel, a partial short in one field will produce excessive heating of that coil, but if the fields are in series, as is usually the case, the partially shorted coil will be somewhat cooler than the others. If they are in parallel the trouble may be detected with an ammeter as the current will be higher through the defective coil. If they are in series the trouble may be detected with a voltmeter by reading the voltage drop across each coil. The voltage will be less across the defective coil. The result of a partial short in a shunt field is to reduce the strength of that field causing an unequal generation of voltage in the armature and a shifting of the neutral point which will usually cause sparking with all its attendant evils.

7. Series Field Poorly Adjusted.—In this article we are referring to the series field of compound machines and not to the straight, series-field motor. Series fields are used to change the field strength in accordance with the load on the machine. In a few cases the series field is made to oppose the shunt field in order to maintain constant speed at all loads and is called the differential-compound winding. In the great majority of cases the series field is

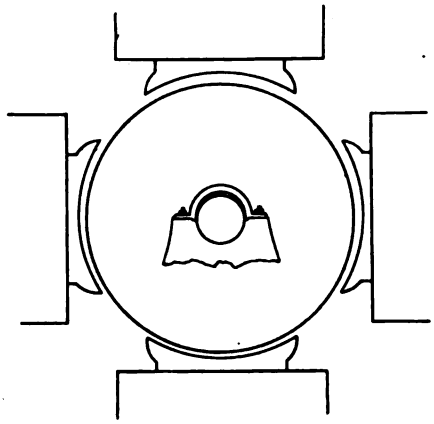


Fig. 5—Section of four-pole motor showing unequal air gaps due to worn bearings.

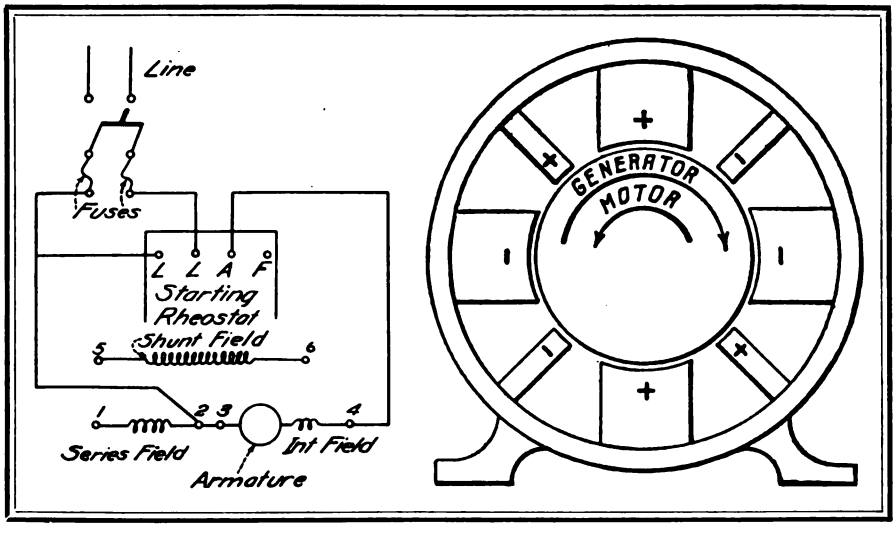
used to assist the shunt field. In a generator it is used to maintain constant voltage or in some cases the field is over-compounded in order to increase the voltage with increased load to compensate for line drop and thereby maintain constant voltage at the load.

In a motor this compounding enables it to carry a greater load and also helps to counteract the armature reactions and prevent the shifting of the neutral point too far for good commutation.

Some series fields have shunt adjustments to regulate the current through the series field and if these are not evenly and properly adjusted or if the series field is not correctly designed, it may result in poor commutation at certain loads, with armature heating due to the short-circuit current under the brushes.

8. Series Field Bucking.—By this we mean one or more of the series field coils opposing the shunt field when they should be assisting. This error is easily made when re-assembling the fields as it may be done either by putting one coil upside down or simply by getting the terminals reversed when connecting the coils together.

Fig. 6—Polarity of interpole fields for directions of rotation of motors and generators and connections for testing correct connections of interpole windings.



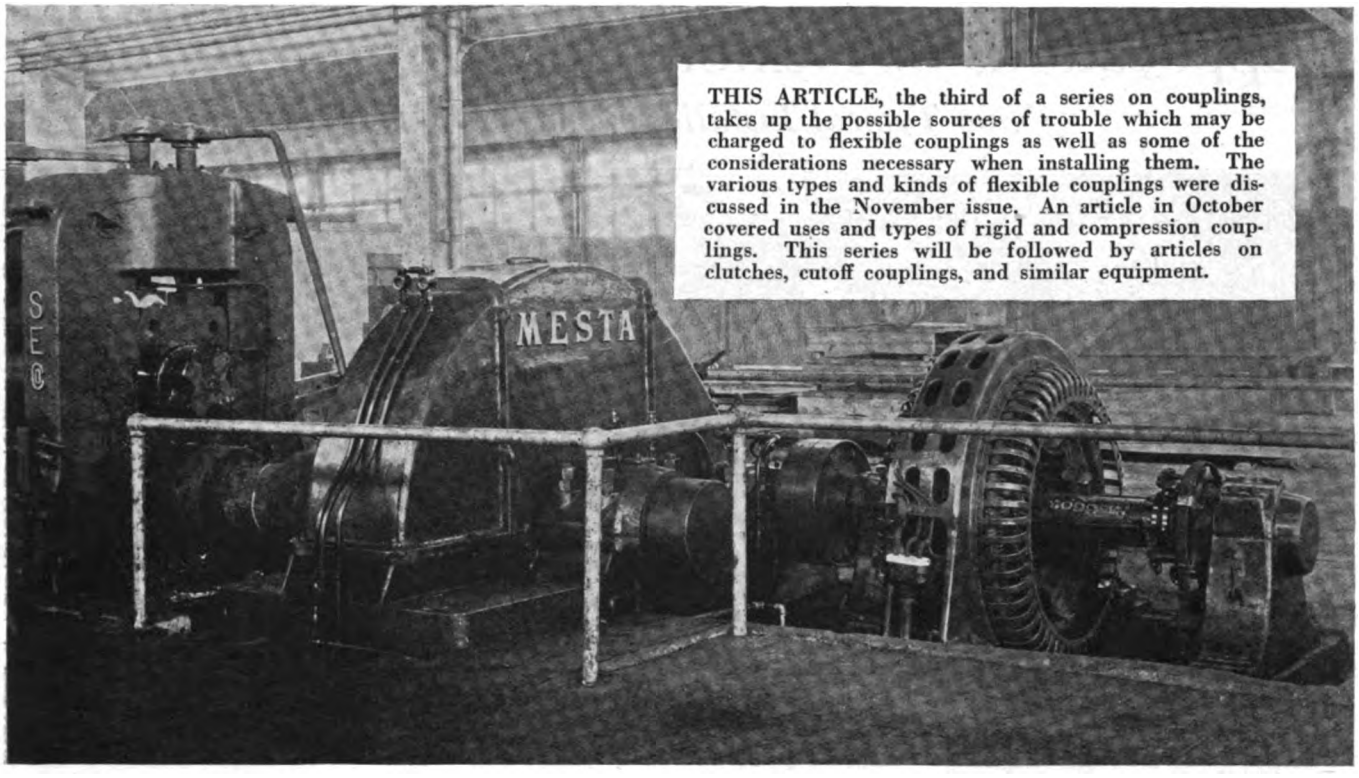
No difference in operation may be noticed with light loads, but with heavy loads the series field weakens the shunt field to such an extent that the pole face is no longer saturated with magnetic flux and the armature reactions overpower the field flux enough to reduce the magnetic flux below the saturation point, which permits of a serious distortion of the field and a shifting of the neutral point. This will throw the coils undergoing commutation in a strong field which will cause heavy short-circuit currents under the brushes, accompanied by severe sparking.

To test for a bucking series field pass current through the shunt fields and by means of a compass mark each field "*N*" or "*S*" depending on which end of the needle is attracted by the pole piece. Next disconnect the current from the shunt field and pass through the series fields taking care to see that the current flows in the same direction as when the machine is in operation. This must be done through some resistance or other means of limiting the current on account of the low resistance of the series winding. It is well to have the test current at least 10 per cent of the full load current to avoid the possibility of residual magnetism in the pole pieces proving stronger than the weak series field. Now repeat the compass test making sure that each pole piece attracts the same end of the needle as in the former test. If any pole piece shows a different polarity that series field is reversed and the leads must be interchanged or the coils turned around. In making this test, care should be taken to bring the compass to the pole piece slowly at the same time watching to see that the needle bearing is free as it is very easy to reverse the magnetism in the average compass needle.

9. Poor Adjustment of Interpoles.—The object of an interpole winding is to produce sufficient flux to offset the armature reactions and maintain a constant field which will produce an approximately constant voltage in a generator or constant speed in a motor,

If sparking or change of speed in a motor, (*Continued on page 612*)

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THIS ARTICLE, the third of a series on couplings, takes up the possible sources of trouble which may be charged to flexible couplings as well as some of the considerations necessary when installing them. The various types and kinds of flexible couplings were discussed in the November issue. An article in October covered uses and types of rigid and compression couplings. This series will be followed by articles on clutches, cutoff couplings, and similar equipment.

Here a 300-hp., 2,200-volt, 60-cycle, three-phase, 300-r.p.m., mill-type, slip-ring induction motor drives a 26-in. cold mill for the International Nickel Company through a bushed pin type of flexible coupling.

How Troubles Charged to

Installation and Operation of Flexible Couplings

Can be Eliminated with Suggestions for Choosing Couplings of the Proper Size

By FRANK E. GOODING
Associate Editor, Industrial Engineer

FLEXIBLE COUPLINGS, as was pointed out in the article in the November issue, which discussed some of the various types and kinds of flexible couplings and their applications, are not intended to take the place of carefulness in installation and a frequent checkup and correction of misalignment. Where trouble is found in the operation of a flexible coupling it can usually be traced to careless or improper installation, neglect after installation, or to a selection of a size or type not suitable for that particular purpose. In this way a flexible coupling is no different from any other piece of equipment as these same three reasons may be attributed as the cause of a large percentage of all trouble with mechanical or electrical equipment.

FLEXIBLE COUPLINGS act as safety links by preventing damage to more expensive equipment from excessive wear, shocks and strains through carrying the brunt of carelessness in installation or operation. Just as electrical trouble has been blamed sometimes on the electrical safety link—the fuse—when it blows, so have flexible couplings been held responsible for some mechanical difficulties due to excessive wear. The remedy is to find and remove the cause, which is generally outside the safety link, instead of merely renewing the fuse or coupling or installing one of larger size.

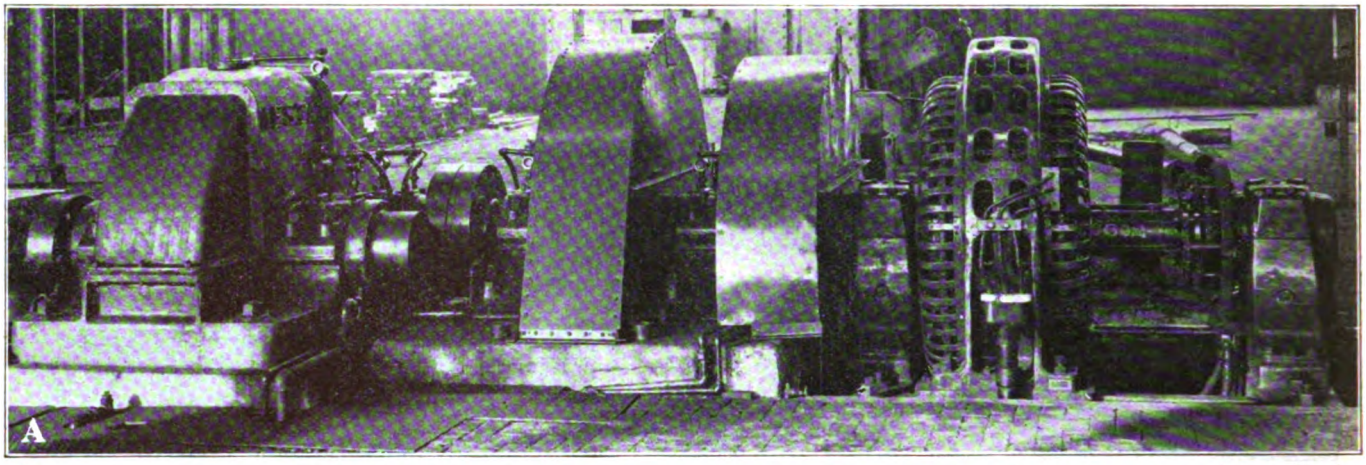
The purpose of flexible couplings is to protect the connected shafts, bearings, gears and the machine itself against destructive misalignment strains. In this way they are comparable to an electric fuse which operates as a safety device in case of overload. A fuse, however, fails when the overload comes on and so protects the equipment by opening the circuit. A flexible coupling, instead, is made almost as strong and frequently stronger than the shaft and so cannot fail in the same way. However, the coupling provides a cushioning effect to smooth out shocks and vibrations and to care for misalignments and in addition serves as a mechanical fuse by bearing the brunt of the wear.

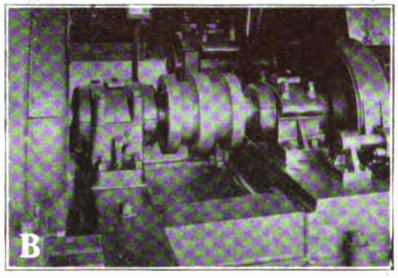
If shafts are properly aligned and frequently checked to see that reasonable alignment is maintained there should be little difficulty in the operation of the flexible coupling, unless the wrong coupling is used or it is neglected. Where it is difficult to keep the shafts in reasonable alignment, something else than the coupling is at fault. The coupling, however, shows the effect of this misalignment and is the safety link which takes the wear. Because it

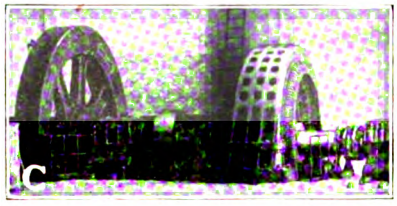
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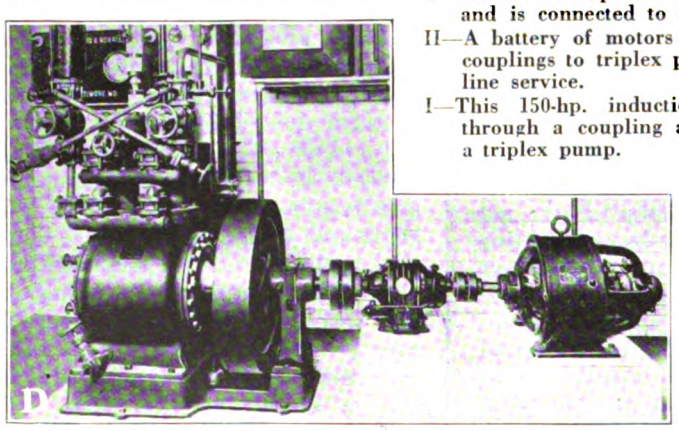
Applications of Flexible Couplings in Industry

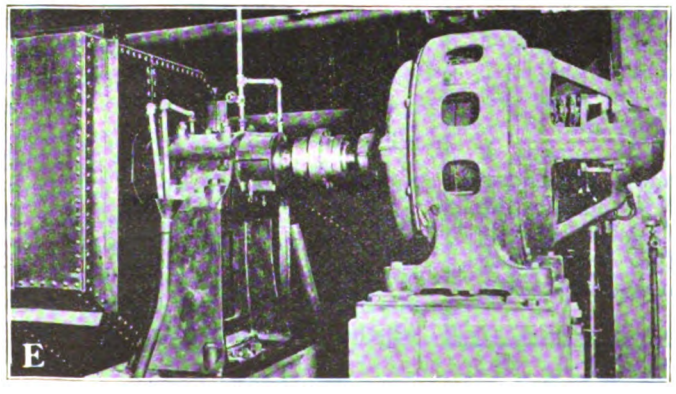
Nine Typical Installations of Various Sizes











A—A 500-hp., 2,200-volt, 60-cycle, three-phase, 450-r.p.m. mill-type, slip-ring induction motor driving a 14-in. Belgian rougher.

B—A close-up of another type of flexible coupling operating between an 850-hp. motor and a mine hoist.

C—A bushed-pin flexible coupling between the 2,000-hp., 83 1/3-r.p.m., 25-cycle, 6,600-volt rolling mill induction motor and the flywheel on a plate mill.

D—Here one coupling operates between the 15-hp. motor at 775 r.p.m. and a reduction gear and another flexible coupling between the reduction gear and an ammonia compressor, running at 155 r.p.m.

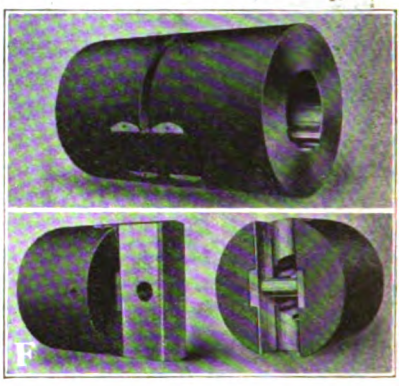
E—A flexible coupling connects the 60-hp., 345-r.p.m. motor to an induced-draft fan.

F—Two views of a universal joint type of flexible coupling sometimes used on heavy-load and low-speed work.

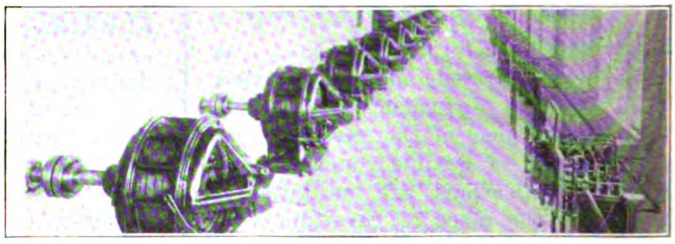
G—Here the 74-hp. motor operates at 1,450 r.p.m. and is connected to a forced-draft fan.

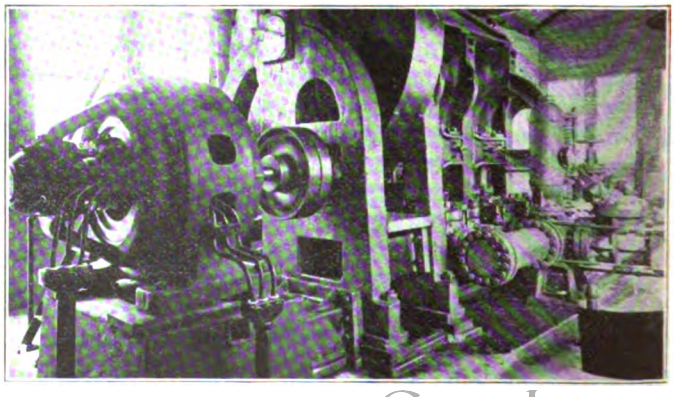
H—A battery of motors is connected by flexible couplings to triplex power pumps for oil pipe line service.

I—This 150-hp. induction motor is connected through a coupling and herringbone gear to a triplex pump.



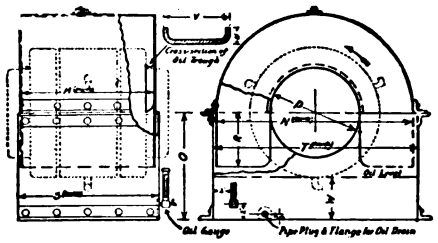






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does wear it is frequently blamed for causing trouble, just as the fuse is sometimes blamed when it blows. In such cases the manufacturer of



One type of oil housing for lubricating flexible couplings.

a coupling, through his wide experience with miscellaneous operating conditions, can usually recommend a method of overcoming as well as for locating the difficulty if he knows the full operating conditions. It should always be kept in mind that where difficulty is experienced in maintaining alignment the installation cannot be neglected and deliberately permitted to run badly out of line and still give satisfaction.

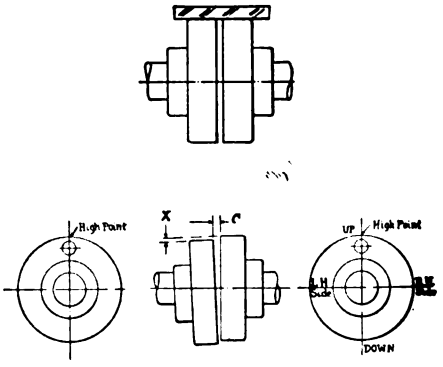
Reasonable care when initially lining up shafts increases the capacity of the coupling to take care of subsequent operating misalignment. How this alignment may be checked up is described later in this article.

If the parts of a coupling show more wear than may reasonably be expected it may be due to any of the following causes: (*a*) Exposure to moisture, dirt, or grit, which may cause rusting or abrasion, (*b*) excessive endwise motion of one or both connected shafts, (*c*) excessive angular misalignment—shafts not parallel, (*d*) coupling too small, (*e*) lack of suitable lubrication. If the coupling is operated where there is likely to be moisture, grit, or dirt, the coupling should be enclosed in a canvas or leather boot or by a stationary sheet metal case, depending upon the speed of operation. Such operating conditions are somewhat unusual and it is best to refer them to the manufacturer for his recommendations. If the coupling is located in a wet or gritty place and does not operate at a peripheral speed greater than 2,500 ft. per min., the space between the flanges may be filled with a medium cup grease and the whole enclosed in a canvas or leather bag wired securely to both halves. Another type of boot can be made by using a strip of single-ply leather belt as wide as the two flanges and lapping the ends. Metal oil cases, as shown in the sketch above, are recommended for high-speed work and may also be used on low-speed operation. Of course, lubrication cannot be used and is not necessary in connection with couplings which depend for their flexibility on rubber, fiber or leather pads or bushings.

In case either or both machines "plunge" or oscillate with respect to the other or to each other, the cause of the unnecessary wear may be removed by leveling up the machines and by using proper locating collars on the connected shafts. For example, sometimes an electric motor has a "magnetic center" or operating point other than that where the rotor shaft operates halfway between the mechanical limit of the locating collars on that shaft. In such a case, by disconnecting the two halves of the flexible coupling and running the motor, the operator can determine the point at which the motor will operate and the spacing of the coupling should be changed accordingly by moving one flange on its shaft or by moving one machine endwise. Each type of flexible coupling indicates the proper amount of space which should be allowed between the flanges for the best operation.

If excessive angular misalignment is the cause of excessive wear, the machines should be leveled up and the shafts lined up. On some types of flexible couplings this angular misalignment can be found by checking the parallelism of the face of the flanges of the two couplings when disconnected by using a steel block and feeler or a steel wedge between the flanges at points diametrically opposite. These should be tested in at least four positions, approximately 90 deg. apart.

When a coupling is found to be too small it is usually the result of having neglected to take into account a maximum peak load. This may be due either to a momentary overload, an excessive r.p.m., to a change in the loading, or to failure to take into account the kind of machines connected as, for example, if a motor drives a reduction gear which in turn is connected to a compressor, the complete installation should be considered. If in addition a flywheel is connected in the lines, its location and effect should be considered in estimating the loading. Frequently after couplings are installed, machines are added or are required to handle material (this is particularly true of mixing and stirring machines) of a much heavier nature than was originally planned and so the load is increased. The solution is, of course, to obtain the proper size coupling. In some cases



These sketches show the method to be used in aligning the couplings and shafts when installed.

and with some types this is possible by a change in size of links or some of the other units within the coupling, so that a complete new coupling is not required.

Couplings operating at high speed and under continuous, 24 hour per day service, or under frequent and repeated reversals, usually require lubrication unless a resilient material is used which will not permit it. This lubrication may be obtained as previously explained. Some types of flexible couplings are so constructed as to retain the oil or grease within themselves and not require additional boots or covers.

A common cause of difficulty with some types of couplings, particularly those which have a flexible pin connection between the flanges, is either too much or too little spacing between the flanges. In either case the improper spacing causes excessive wear upon the pins and the units retaining the pins in position. The difficulty, of course, shows up in excessive wear of the coupling which, as previously stated, acts as a safety link or fuse in the unit. The proper procedure is, of course, to see that the correct spacing is obtained between the flanges. This may be done in some cases by moving the flanges; if this is not possible a machine must be shifted. In other cases the coupling may appear to pull the shafts together or push them apart. Usually the real cause of this will be found to be an unbalance of one of the connected machines, the machines are out of level, or there may be some internal or external pressure of one of the machines. If the flanges are disconnected or connected loosely and operated, it is sometimes found that under load the

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flanges will open up or close more or less than the intended spacing. After the cause has been corrected the flanges should be connected up as intended.

When ordering parts for a coupling from the manufacturer, the serial number of the coupling, which is usually found stamped on the coupling flange, as well as any other information given there, should be included. From this serial number in nearly all cases the manufacturer can locate the particular size and type of coupling and also obtain from his records the bore and other dimensions included in the original order. The quantity required and shipping directions are also obviously necessary. It is well, in case of broken parts, if the user has not discovered the cause of the difficulty, to send some of the worn parts or at least completely describe the extent and location of the wear to the manufacturer, as his experience will usually help to locate the source of the trouble and also assist in its correction. It does little good to install new parts without correcting the condition which caused the excessive wear or breakage.

Some Suggestions on Alignment of Flexible Couplings

The exercise of due care to obtain good initial alignment of the shafts will provide greater capacity to the flexible coupling to take care of subsequent operating misalignments. Any specification of definite limits is difficult; the greater the speed, the greater the care desirable. Most turbine builders line up their machines initially within 0.002 in. to 0.004 in. On lower-speed, heavy-duty drives 0.01 in. is good practice, easily obtained without micrometer gages. Perhaps the best advice is to line up as carefully as possible with the tools available. Occasionally after operation the alignment should be checked and corrected if necessary.

Before lining up initially and whenever convenient in rechecking alignment, remove flexible pins (or coupling bolts). Also level up.

To line up a flexible coupling use a steel straight edge across both flanges in four positions at approximately 90 deg. intervals. Shim up the lower machine all around or move one machine sidewise, or both, so that the straight edge will lay flat across both flanges at all four positions. Next use a steel block and feeler (or a steel wedge) between flanges at four similar positions. Shim up one end of one machine or move this end sidewise, or both, pivoting around the coupling until these four spacings also are the same.

To obtain exact initial alignment and to correct for any possible eccentricity of the individual flanges, first find and mark with chalk the high points of the individual flanges by rotating them separately and then put the high points together. Insert one flexible pin (or a loosely-fitting through bolt) so that flanges may be turned over together by hand. When turning them over consistently crowd the flanges either apart or together. Take readings for both X and C, as shown in the sketch (page 581), between the same points as the two flanges at the four positions.

If C does not measure the same at all four positions, one machine should be pivoted around the coupling by shimming at one end or by sliding at that end, or both, until all the measurements are the same. If the measurements for X are not the same at all four positions then one machine should be shimmed up all around or should be moved sidewise, or both, until these four measurements also are the same.

In special cases or if flanges are of a dis-similar diameter, use a C clamp and offset arm with a pointed setscrew. With a feeler obtain measurements for X as above between point of setscrew and periphery of flange. Scribe a line on this flange and obtain measurements from point of setscrew to this line, as for C above. In both cases revolve flanges together, crowd them apart or together, and correct for the misalignment as above.

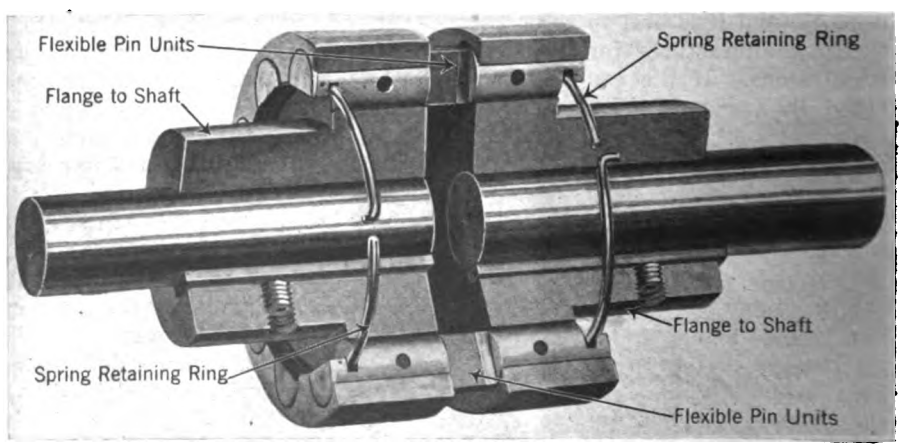
A turned or ground bar for a sliding fit in the pin holes will serve instead of a straight edge across the flanges. This will also test for concentricity of pin circle diameter with respect to bores or flanges.

After all readings for both C and X have been finally checked as correct, set up bolts and dowel machines in place. If a machine is to be redoweled after correcting for misalignment, do not use the same dowels and holes, but drill and ream new holes, or ream out the old holes and use larger dowels.

Points to Consider When Specifying Flexible Couplings

When ordering a rigid or compression coupling for a lineshaft drive as was mentioned in the article in October, it is only necessary to give the diameter of the shaft, as these couplings are designed and in a measure standardized to transmit the rated horsepower of the shaft. The critical point, then, is in the selection of the proper size of lineshaft, which will not be considered in this article.

Flexible couplings should be selected in an entirely different way. Because manufacturers of motors, turbines, mills and other machinery frequently are called upon to design a shaft to sustain a heavy bending load, as of a mill or the rotor of a motor, generator or turbine, in addition to the twisting or torsional load due to power transmitted it is absolutely necessary to make, in many instances, much larger shafts than the horsepower or rating alone would call for. To meet this, practically all flexible coupling manufacturers have standardized their



A phantom view of one type of flexible coupling.

Here the flexible units are made up of laminated pins of spring steel fastened together at each end and held in position so that they do not turn by the steel retaining rings. If it should be necessary to remove one of these flexible steel pins, it is only necessary to slip out these spring retaining rings and insert a new pin.

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Rating Factors for Determining Size of Flexible Coupling for Various Loads and Drives

Kind of Apparatus	Factor*
Steam-turbine centrifugal pumps, blowers or other smooth load	1¼
Turbo-generators, motor-generators	1½
Motor-driven centrifugal pumps, blowers or other smooth load	1½
Motor-driven woodworking machinery, shafting	2
Motor-driven conveyors, screens, beaters, with no pulsation	2
Motor-driven four-stroke (duplex, double-acting) pumps	3½
Motor-driven triplex (single-acting) pumps	3½
Gas engine triplex (single-acting) pumps	5 to 6
Motor-driven crushers, tube mills, hogs, pulverizers	4
Motor-driven rolling mills, steel, rubber or brass	4
Motor-driven mine hoists, elevators, cranes, screw downs	4
Gas or steam engines with flywheel, to smooth load	3 to 5
Motor-driven compressors	6
Engine-driven fans, engine mine fans	8

*Note.—Multiply the horsepower transmitted per 100 r. p. m. by the factor given in the above table; this gives the actual service load on the coupling.

method of rating couplings to a definite horsepower per 100 r.p.m., and a maximum possible bore. That is, the first consideration is the power requirements and the second consideration is the bore. Some manufacturers are rating their couplings and calling them by the size number corresponding to the rating to emphasize this point.

For example, suppose a flexible coupling is desired for a 50-hp. motor operating at 1,200 r.p.m. with the largest shaft 2⅝-in. diameter. The first step is to reduce the motor rating to terms of hp. per 100 r.p.m. To do this divide the horsepower by the r.p.m. and multiply by 100. In this instance, the rated load will be 4⅙ hp. per 100 r.p.m. The second step is to multiply this rated loading by the service factor for the particular duty as recommended by the coupling manufacturer. This is *important*. The result is the required coupling hp. per 100 r.p.m. and it should be compared with the manufacturer's rating. For example, for a motor-driven centrifugal pump where the motor may have overload rating of 50 per cent, a service factor of 1½ might be recommended. In such a case a coupling rating of 4⅙×1½, or 6¼ should be used. However, if this motor is to be connected to an elevator load where the motor has 100 per cent overload capacity and where the service is intermittent or subject to frequent reversal, then a service factor of four (4) might be recommended. In this case the coupling rating required would be 4⅙×4, or 16⅔ and a larger coupling having more power capacity should be used.

After a coupling has been selected with sufficient power capacity it should, of course, be determined whether it has sufficient capacity for the largest shaft and sometimes the largest shaft may require a coupling having more power capacity than is needed for the load alone.

Consulting one manufacturer's table (this would vary according to the different types and makes of flexible couplings) one size has a maximum bore of 2⅝ in. which is satisfactory, and a horsepower rating of 9 per 100 r.p.m. However, as this is lower than required (16⅔), the next size, which has a maximum horsepower rating of 28 and a maximum bore of 3 in., must be selected. The maximum recommended speed for this size is 1,900 r.p.m., which is well over the actual speed.

It is important to give the manufacturer the following information concerning any installations when ordering a flexible coupling as his recommendations, based on experience, are very desirable: (1) Normal horsepower rating; (2) normal r.p.m.; (3) kinds of machines (both driver and driven) and operating service; (4) dimensions of both bores and keyway sizes required.

Occasionally special operating conditions will prevail and it may be well to add the following service information: (5) Maximum overload; (6) is service reversing or non-reversing? (7) variable or constant speed; (8) is a flywheel used and where is it located? (9) what is the available space to accommodate couplings?

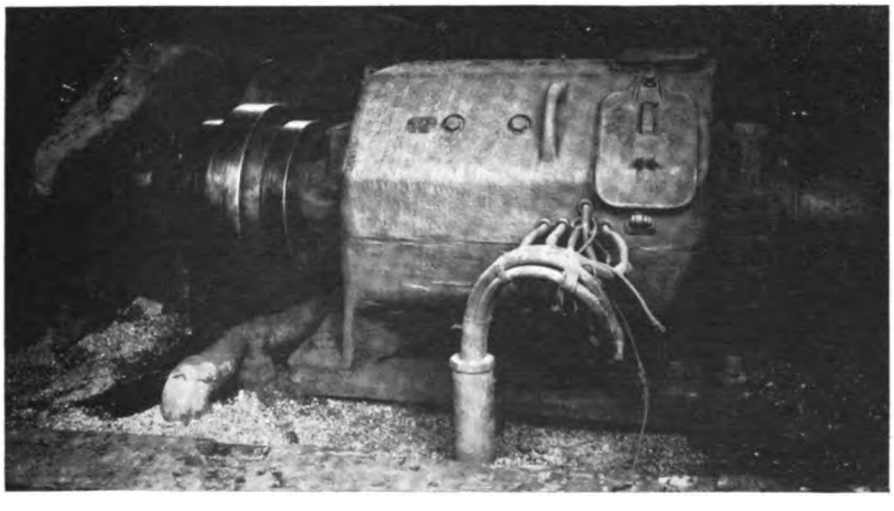
Some of the other factors to be considered when ordering flexible couplings are that occasionally care must be taken to see that the coupling is not so large in diameter as to have a flywheel action. This is particularly necessary in reversing drives. Other factors are end-thrust and back-lash in the gearing of the machinery driven, particularly when reversing.

Lubrication is an important operating condition in certain types of flexible couplings, particularly those in which metal parts are in flexure or slide on each other. The manufacturer usually provides some means of lubrication and specifies the type of lubricant to use. Lubrication, where necessary, cannot be neglected without causing trouble and flexible couplings are no exception.

In summarizing it may be well to again emphasize the three most important points to consider in the installation and operation of flexible couplings. In the first place a flexible coupling is *not* intended to take the place (*Continued on page 590*)

Another well-known coupling is here used in steel mill work.

In this installation a flexible coupling connects a 100-hp., mill-type reversing motor driving a blooming mill table. The motor operates at 580 r.p.m. but the coupling is connected to reducing gears which drive the rolls.



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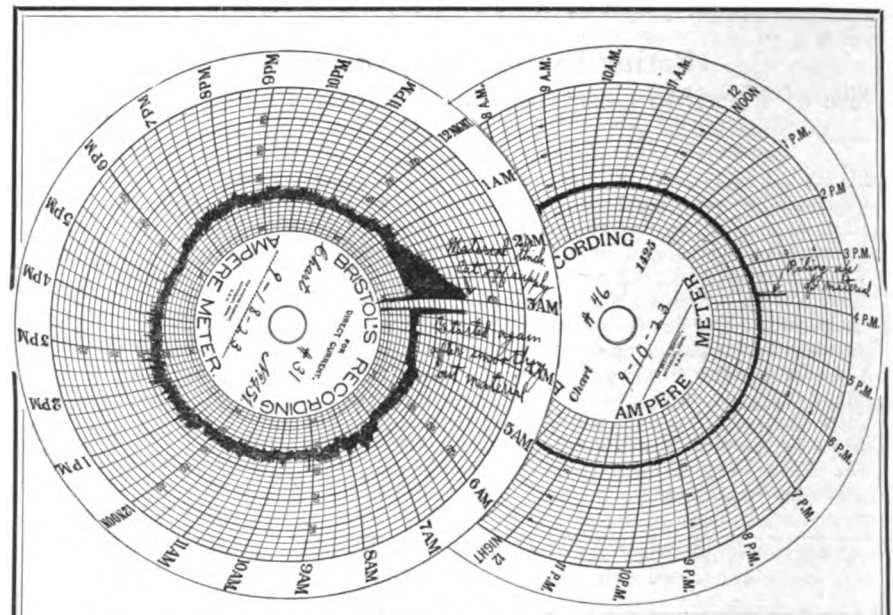
Here Is a Case Where a

Graphic Meter as a Watch Dog

For Overloads and Abnormal Service Conditions Prevents Breakdowns and Costly Repairs

By J. ELMER HOUSLEY

Electrical Engineer, Aluminum Ore Company, East St. Louis, Ill.



These graphic charts showed overloads that were removed before damage was done. When the overloads reached the danger point the operators stopped the machine and lightened the load. Note the smoothness of the alternating current curve shown at the right, while the direct-current chart at the left shows practically every load fluctuation.

THERE ARE many motor-driven process machines whose loads fluctuate widely and will at times overload the machine or the motor if they are not closely watched. About the only way of keeping a check on some of these machines is by using an electric meter, a graphic ammeter being particularly applicable to such work. The use of a graphic meter will prevent serious breakdowns which involve heavy repair bills as well as costly production losses. It may also detect other faults in the operation of the machine, such as running below capacity, irregularity of feed, and so on.

As an example of the benefits that may come from employing a graphic meter, it may be well to mention the case of four stirring machines in the Aluminum Ore Company's plant. Before installing the meters, one of these machines was out of service on an average of once every two months on account of overload which damaged the stirring device. A breakdown of this kind cost about $500 for repairs and a 25 per cent production loss. Since installing the meter we have experienced no breakdowns of this nature.

In "preventive" maintenance as affecting both the electrical and mechanical equipment, the chart of a graphic meter furnishes an invaluable record from the standpoints of both the engineer and the production superintendent. The engineer is interested in the time the drive is in operation over a given period showing the operating ratio which may be compared with an arbitrary normal. The lengths of interruptions are recorded and may be properly charged against the causes of the interruptions, whether from mechanical or electrical trouble and if originating through negligence of the operating staff.

The operating superintendent should be interested in the ammeter chart since it will indicate whether or not he is securing maximum output from a given machine. Furthermore the quality of the product is sometimes visually indicated by the varying line on the chart. In mixing operations involving arms and paddles in contact with materials which may vary in consistency, it is up to the man operating the machine to see that conditions do not arise which would throw such a load on the machine that it would wreck the stirring or agitating devices or burn out a motor.

The graphic record which goes on through the long watches of the night keeps the operators on the alert as they know they have a guide to follow constantly and any lapses in their vigilance will go on record against them. Often an investigation will indicate that the majority of preventable accidents to production machinery occur at night. The best method to reduce the number of such accidents is to secure some graphic record of the conditions surrounding past occurrences. Negligence cannot, of course, be eliminated by meters but responsibility put on the individual employe will often produce results impossible by other agencies.

Where the mixing devices may be raised or lowered or where the speed of the drive may be varied, the use of the recording meter permits close regulation of the mixing process. Where the drive is an agitator, quite often the consistency of the batch should be (*Continued on page 611*)

Mr. Housley points out that:

Before installing these meters certain machines were out of service on an average of once every two months. The repair cost was about $500 with 25 per cent loss in production. No breakdowns have occurred since the graphic meter was installed. Investigations have indicated that the majority of preventable accidents occur at night. Graphic records of conditions surrounding these occurrences help to provide the means to prevent them. Besides, the graphic meter can be used to check the performance of equipment from various locations where work may require the presence of the operator.

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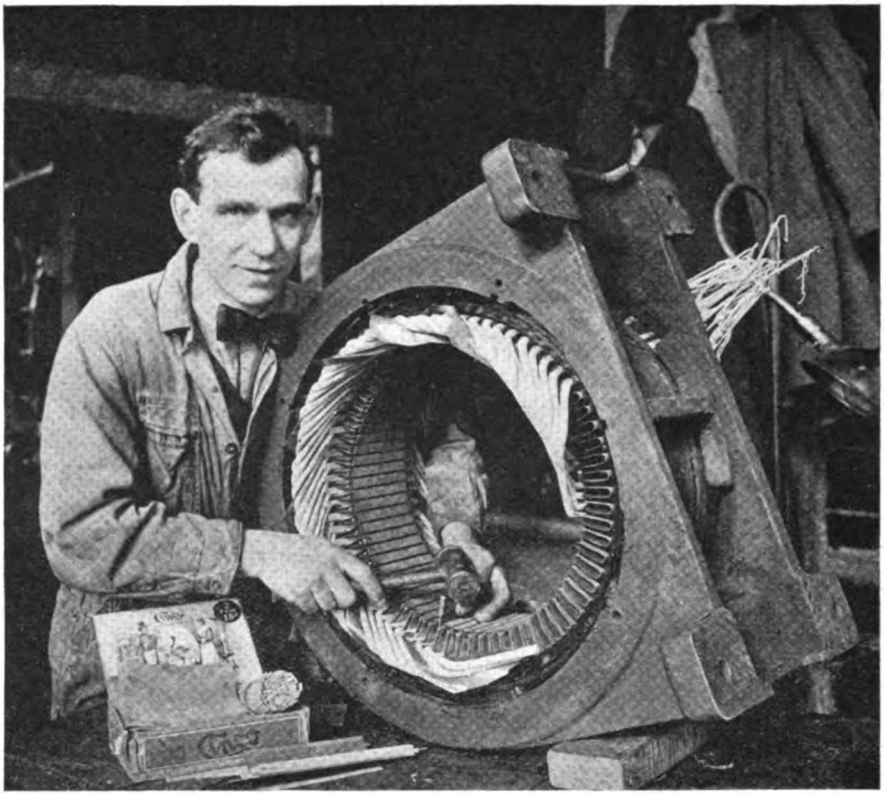
Diagrams and Information on

Two-and Four-Speed Windings

With Connections for Salient and Consequent Poles and the Possible Changes Outside the Motor

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company



The slots in this motor, which is being wound for four speeds, are made extra deep to take a double winding.

SOMETIMES an induction motor is wound to give two speeds or four speeds, with the changes in speed effected by making various connections outside of the motor. Two different speeds may be obtained from one winding arranged to give two different numbers of poles. Usually the higher speed is obtained by the ordinary type of connections giving a certain number of salient poles. The lower speed is obtained by connecting the winding for twice as many poles, which are in this case "consequent" poles. These are explained in a later paragraph.

The four-speed winding is a combination of two of the two-speed windings placed in the same stator. Usually the two windings are located in the same slots, which are made extra deep especially for this purpose. A stator with slots of this kind is shown in the photograph at the beginning of this article. The two, two-speed windings, for instance, may give respectively four and eight poles, and six and twelve poles. A winding of this kind is described in what follows.

Difference Between Salient and Consequent Poles

The ordinary type of winding for induction motors is connected to give what are called salient poles. With a salient-pole connection there is one magnetizing group of coils per pole (for each phase). In other words there are as many poles as there are groups. With the consequent-pole arrangement one group of coils forms two magnetic poles and, therefore, there are twice as many poles as there are groups of coils per phase. An inspection of Fig. 1 and Fig. 2 will help in understanding the arrangement of these two types of poles. In Fig. 1 is shown the frame of an ordinary direct-current motor. In *A* of Fig. 1 there are four field windings arranged, as they usually are on a direct-current motor, to give alternately north and south poles. This is the same connection of poles as that usually employed in an induction motor and the poles in this case are salient poles, each one being surrounded by a coil. The dotted lines indicate the path of the lines of magnetic force. The next drawing, *B*, in Fig. 1 shows the same motor frame, but in this case it has only two coils. As before, the first of these coils is connected to give a north pole and the second to give a south pole. A two-pole winding is the result, the magnetic flux following the dotted line shown in the drawing. These two poles are again salient poles, each one being surrounded by a coil.

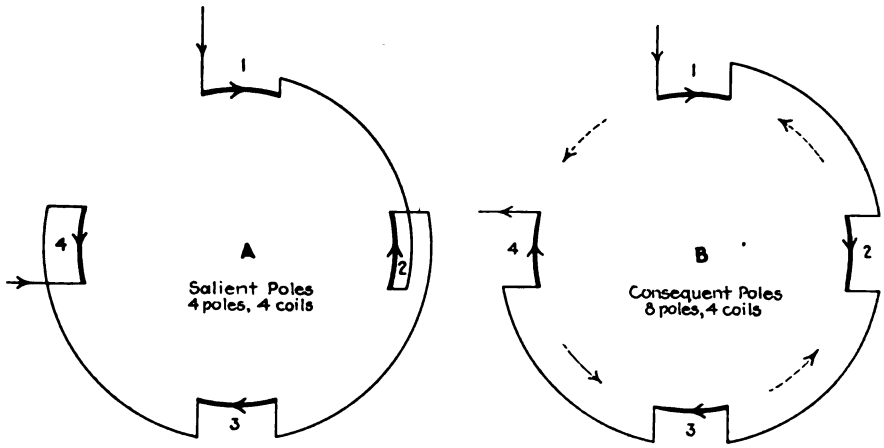
Now if we reverse the polarity of the field coil on pole 3 the result will be four consequent poles. At poles 1 and 3 there will be two north poles and as there must be a return path for the magnetic flux, the lines of

AN INDUCTION MOTOR which will give two speeds has a winding only a little more complicated than the ordinary single-speed motor. In fact the only requirements which are not necessary in the single-speed motor are: (1) That "consequent" poles must be employed. (2) The coil pitch must be kept low. (3) A larger number of leads are brought to the outside of the motor. This article treats particularly these points. Salient and consequent poles are fully explained and their application shown. This brings in a discussion of the proper chord factor. Typical diagrams explain the connections of three different types of two-speed windings. When the two-speed motor is understood, the four-speed motor is easy because this is only a combination of two two-speed windings.

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Fig. 2—Four salient poles or eight consequent poles from the same winding.

These are single-line diagrams showing four coil groups in each case, which represent one phase of a winding. In *A* these groups are connected top-to-top so as to give alternate polarities on alternate groups, resulting in four salient poles. In *B* the same groups have been connected for eight consequent poles by reversing groups 2 and 4. A motor connected as at *B* will run at half the speed of that at *A*.



force from poles 1 and 3 after meeting in the center of the air gap diverge to the right and left and enter poles 2 and 4. Thus poles 2 and 4 become south poles and there are altogether four consequent poles. To get the same magnetic density on the consequent poles as in the salient poles in *A* and *B*, the two coils in *C* must have twice the number of turns with the same current flowing as the coils in *A* and *B*.

Thus it is seen that we can change the two-pole winding at *B* into a four-pole winding, as at *C*, by reversing the polarity of one coil, which is the same as making all the field coils of the same polarity. This is the same principle that is applied in the case of two-speed windings for induction motors, the only difference being that the alternate *groups* of coils are changed instead of the single coils as shown in Fig. 1.

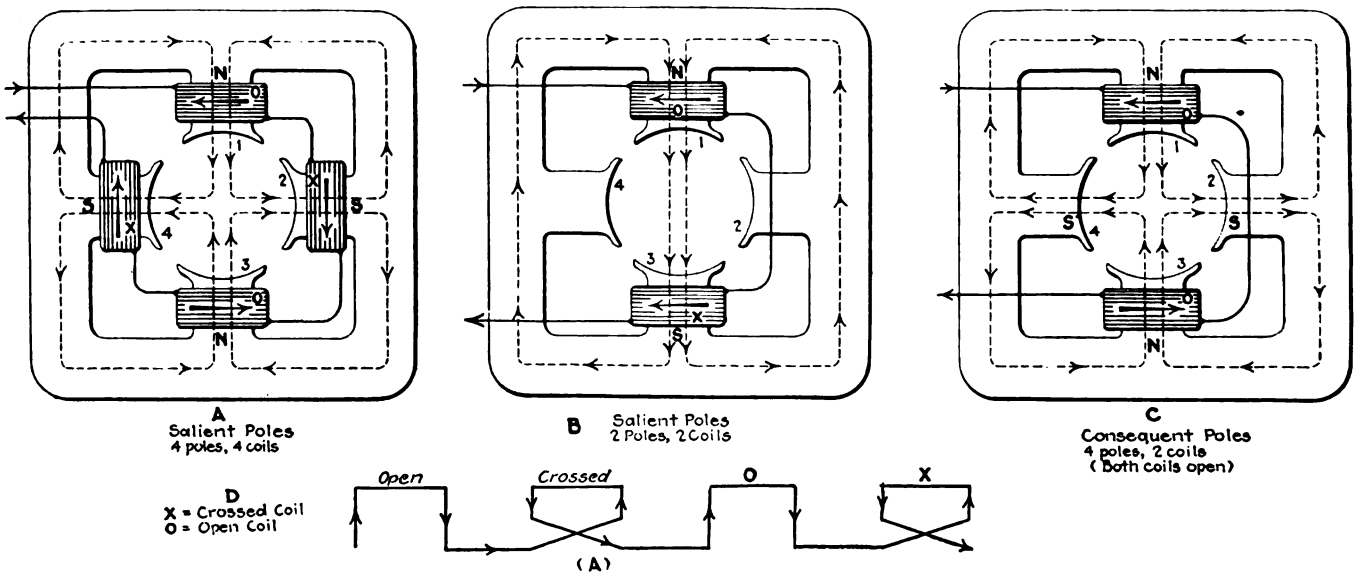
In Fig. 2 the principle which has just been explained is applied to a single-phase, four-pole, line diagram. At *A* of Fig. 2 four groups of coils are connected as in the ordinary manner, alternate groups having opposite polarity. The groups as connected in *A* give four poles which are in this case salient poles. To change the winding so that the same coils will give eight consequent poles the connections to groups 2 and 4 are reversed making these two groups of the same polarity as groups 1 and 3. This will form four poles of one polarity and cause four other poles of an opposite polarity to be formed between each pair of groups. This gives eight poles as shown in *B*.

In the motor shown in Fig. 1 there would, of course, be considerable leakage of magnetic flux particularly in diagrams *B* and *C*. For the sake of illustration, however, this leakage can be disregarded. In the case of induction-motor windings, although there is some leakage, it is not nearly so great as that in the machine shown in Fig. 1.

It may be well to explain here the terms "open" and "crossed" coils, which are mentioned in Fig. 1. In *A* of Fig. 1 there are two open coils and two crossed coils as shown in the small diagram at *D*. An open coil is one from which the starting and finishing leads are brought out straight, as shown in the first coil of the small diagram *D*. In a crossed coil the starting lead and the finishing lead are crossed and brought out on opposite sides as shown in the second coil of diagram *D*. In an induction motor an entire group of coils may be of the crossed type and this will permit of a short jumper between this group and the next adjacent to which it is connected, in case the groups are connected for salient poles as shown in *D*. The jumper is connected to the adjacent end of the crossed-coil group and does not have to pass across the coils to the further end of the group. In *B* of Fig. 1 the coils alternate open and

Fig. 1—The difference between salient and consequent poles.

At *A* and *B* are examples of salient poles, while at *C* there are four consequent poles. Drawing *A* shows the usual arrangement where four coils (or groups) form four salient poles. Drawing *B* shows two salient poles formed by two coils. The four consequent poles in drawing *C* are formed by reversing one of the coils in *B*. The result is two north poles at the coils and two south poles formed by the flux returning into the iron. The direct-current motor frames are shown in these drawings only for the sake of making the principles clear. These same principles hold for any type of winding used in induction motors. In the windings of modern induction motors, a group of coils replaces each coil in the diagrams shown here. The diagram at *D* shows the difference between an "open" coil and a "crossed" coil.



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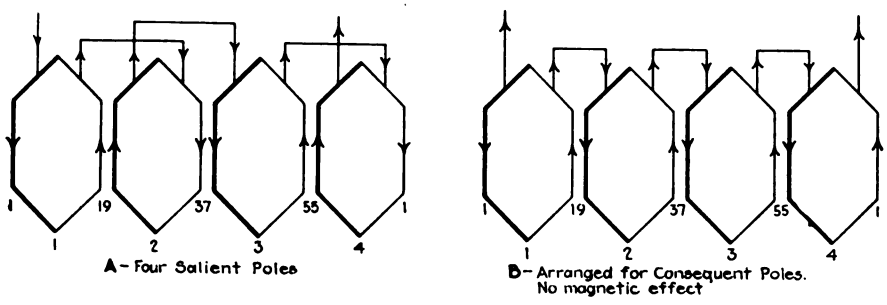


Fig. 3—A full-pitch, salient-pole winding cannot be reconnected for consequent poles.

The drawing at *A* represents a four-pole winding with seventy-two slots wound with full pitch. Each coil shown stands for a coil group. As may be seen from the arrows which show the direction of current flow, the currents in drawing *B* neutralize each other and the result is zero magnetizing current. If the pitch of the coils had been less than 1-and-19 there would be some magnetic flux set up in *B*. In practice the pitch should not be over 80 per cent of full pitch.

crossed as they do in all salient-pole connections. In *C*, however, all of the coils are open coils, giving consequent poles.

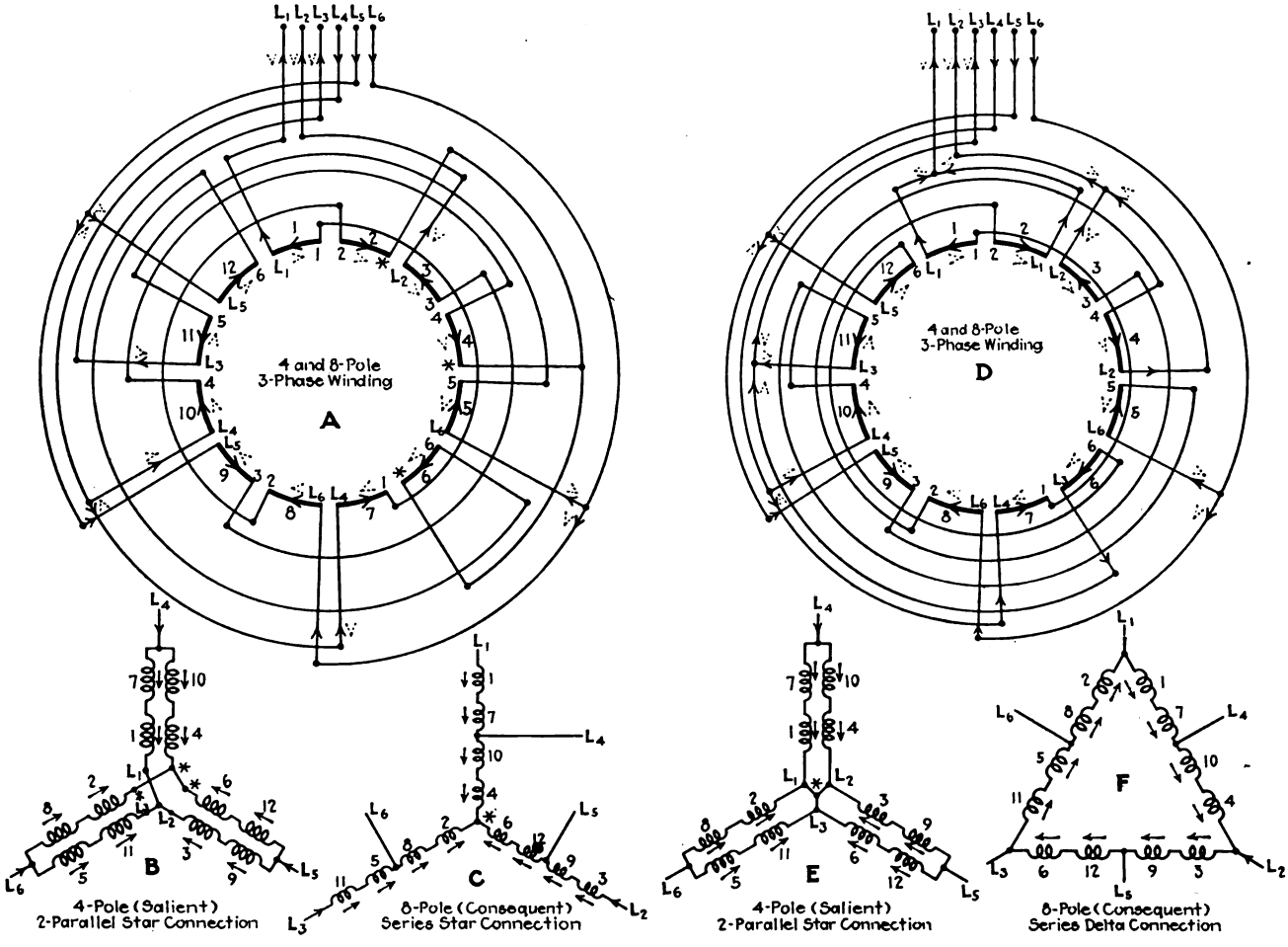
Grouping and Pitch Used With Two-Speed Windings

When an induction-motor winding is arranged for two-speed operation the coils are formed into groups of the same size as they would be for a winding which is to operate at the higher speed (lower number of poles). For example, suppose that a motor with seventy-two coils is to be arranged for four and eight poles in a three-phase connection. Then figuring on the higher speed or four poles, there would be $3 \times 4 = 12$ groups. Then $72 \div 12 = 6$ coils per group.

The coil pitch is usually made full pitch for the low-speed winding. In the case mentioned it would be full pitch for the eight-pole connection. As there are seventy-two coils, the pitch would be $72 \div 8 = 9$, which is a pitch of 1-and-10. This gives a chord factor of 100 per cent for the low-speed winding. With this coil throw the coil pitch for the high-speed winding is one-half full pitch. This gives a chord factor of 0.707. Of course these pitches may be varied for special conditions, but they serve very well for the two most common cases for which two-speed motors are employed. The first of these is the case in which the torque is to be kept practically the same at both speeds. The second condition arises when the horsepower is to be kept the same at both speeds. These two conditions can be met with fairly simple connections, using the

Fig. 4—Two examples of two-speed windings.

The winding at *A* gives the same torque at both speeds, while the winding at *D* gives the same horsepower at both speeds. These windings are both for four poles and eight poles. The dotted arrows in *A* and *D* show the direction of current for the eight-pole or low-speed connections, and the full arrows show the current direction for the high-speed connections. The small diagram *B* shows the four-pole connection for diagram *A*, which is a two-parallel star connection. The eight-pole connection is shown at *C*, which is a series-star connection. Six leads are brought outside the motor. The external connections of drawing *A* should be as follows: for four poles, line leads to L_4, L_5 and L_6; L_1 to L_2 to L_3. For eight poles the connections are: line leads to L_1, L_2 and L_3; L_4, L_5 and L_6 open. As shown at *E*, the four-pole connection of diagram *D* is two-parallel star, while the eight-pole connection is series-delta, as shown at *F*. The external connections for this winding are as follows: for four poles, line leads to L_4, L_5 and L_6; L_1 to L_2 to L_3. For eight poles the connections are: line leads to L_1, L_2 and L_3; L_4, L_5 and L_6 open.



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coil pitches just mentioned. When calculating the horsepower, and so on, for windings arranged for two-speeds the different distribution factors of salient-pole connections and consequent-pole connections must, of course, be taken into account. Information on distribution factors for various kinds of connections was given in an article by A. M. Dudley, in the July issue of INDUSTRIAL ENGINEER.

The motor connected in the ordinary manner for salient poles can be reconnected for twice the number of consequent poles providing the coil pitch is not over 80 per cent of full pitch. Of course with any pitch which is below full pitch it is possible theoretically to get consequent poles, but with a pitch greater than 80 per cent of full pitch of the original winding the consequent-pole arrangement will give comparatively little power. When the coils are connected for full pitch on the original salient-pole winding, no power at all will be delivered if the same groups are reconnected for consequent poles. This fact is illustrated in Fig. 3. At *A* of Fig. 3, is shown a diagram representing a four-pole motor having seventy-two slots. Full pitch would be $72 \div 4 = 18$, or a pitch of 1-and-19. Then laying out four coils, each to represent a pole group, the bottom half of coil 1 is in the same slot as the top half of coil 2. This is slot No. 19, as shown. Likewise, halves of coils 2 and 3 are in the same slot, halves of coils 3 and 4, and halves of coils 4 and 1. This gives four salient poles. The arrows representing the direction of current, on both halves of the coils in each slot, point in the same direction. At *B* in Fig. 3, the winding has been reconnected to give eight consequent poles. In this case, however, the arrows on the two half-coils in each slot point in opposite directions, and therefore the currents have no magnetizing action upon the core.

In the case shown in Fig. 3, if the coil pitch had been 1-and-14, the re-

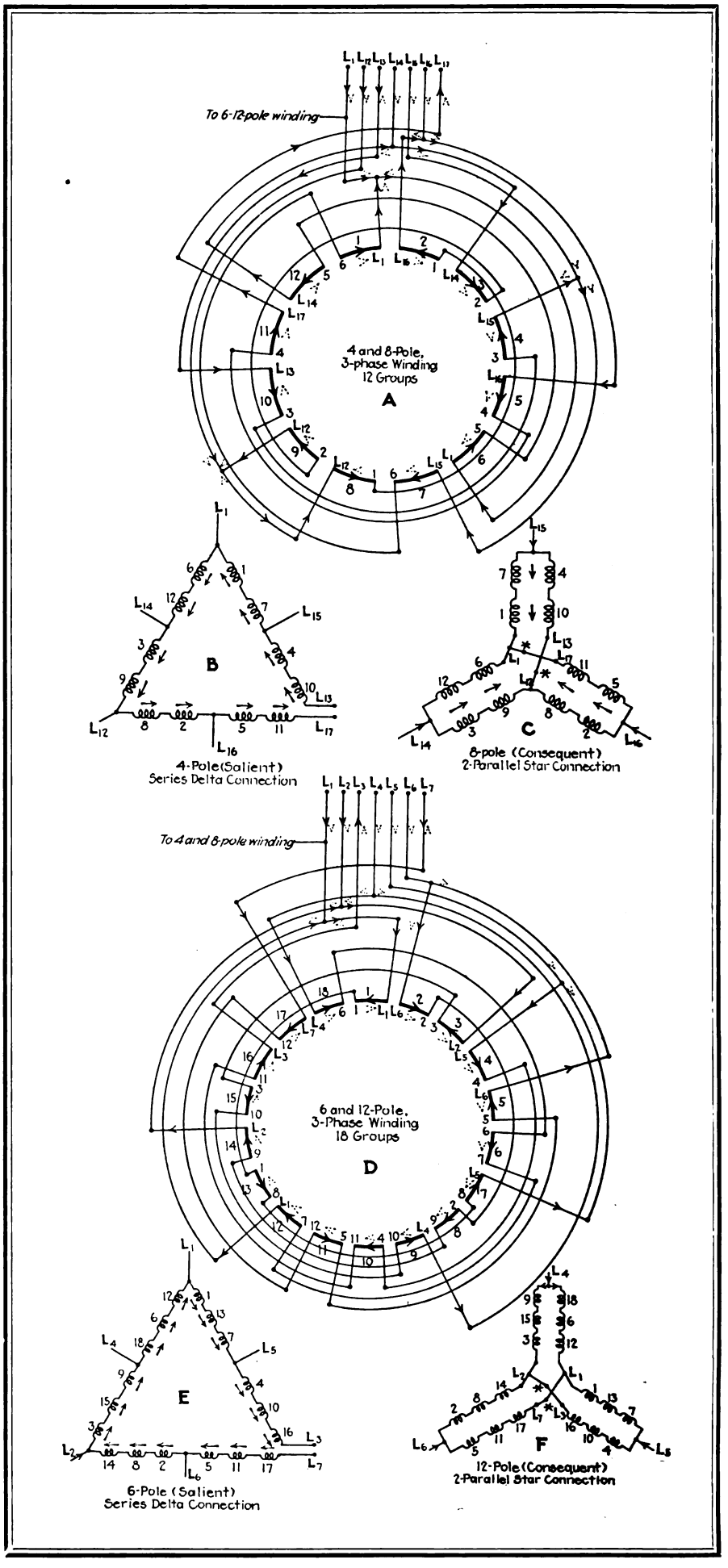


Fig. 5—Windings for a four-speed motor.

This consists of two, two-speed windings giving respectively four and eight poles, and six and twelve poles. The dotted arrows on the diagrams denote the current direction when the windings are connected for the greater number of poles. The higher speeds on each winding are obtained by series-delta connections, while the lower speeds are secured by two-parallel star connections. Thirteen leads are brought to the outside of the motor, one of these tying to lead No. 1 of each winding. The connections for the controller of a motor with such a winding are shown in Fig. 6.

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connected motor would have operated. However, the nearer the coil pitch approaches 100 per cent of the low-speed full pitch, the better will be the results obtained, in most cases, with the consequent-pole connections.

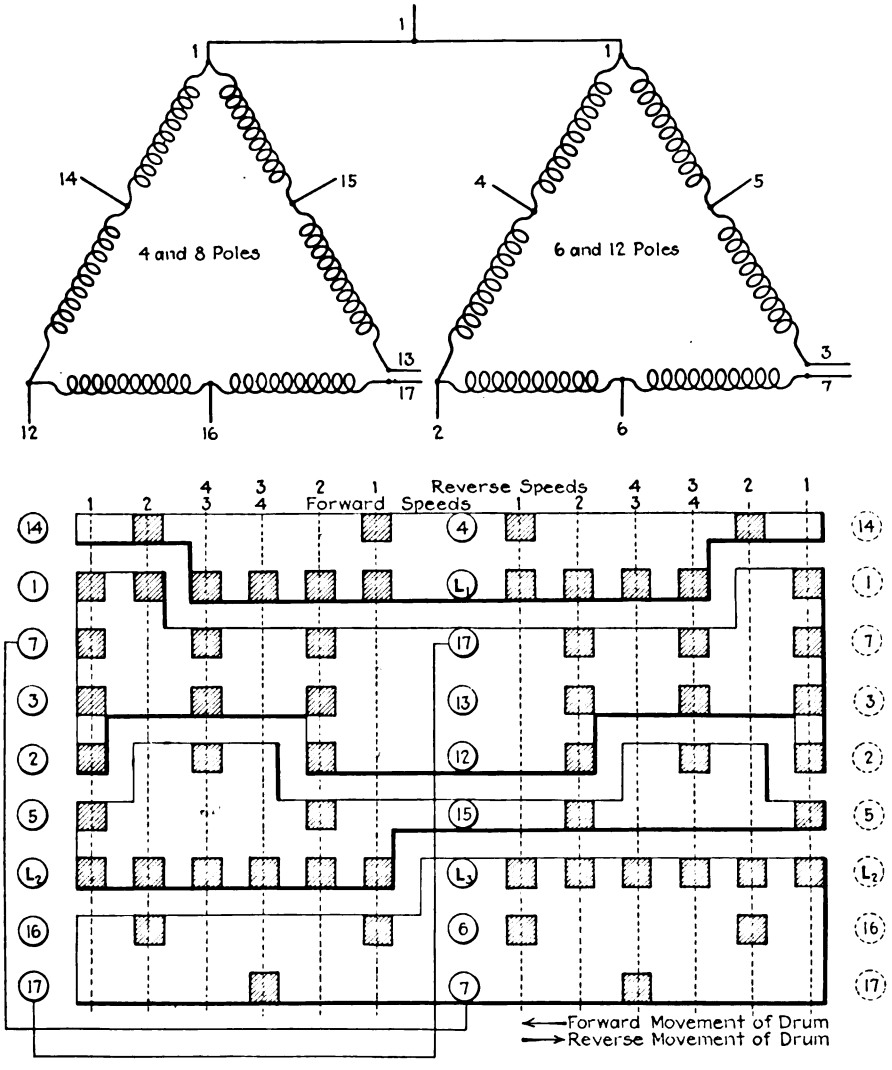
Two-Speed Windings Designed to Give Constant Torque

A two-speed connection which will give the same torque at both speeds is shown in *A*, *B* and *C* of Fig. 4. The high-speed connection is for four poles (salient) and the low-speed connection is for eight poles (consequent). In a motor connected in this way six leads are brought to the outside of the motor. A long-jumper type of connection is used and a tap is made at the center of each phase. The full arrows in the diagram at *A* show the direction of current for the four-pole or high-speed connection while the dotted arrows show the current direction for the low-speed connection. For the low-speed connection, which is shown by the small diagram at *C*, the connection is series star. One permanent star connection is made inside the motor, connecting groups 2, 4 and 6. From diagram *A* it will be noted that the dotted arrows, which show the current direction for the lower speed, are all in the same direction.

The high-speed connection which is shown by the small diagram in *B*, is a two-parallel star arrangement. The permanent star connection between groups 2, 4 and 6 forms one star, while another star is formed by connecting together the leads L_1, L_2 and L_3. Then the line leads are connected on to L_4, L_5 and L_6. Checking the current through according to the full arrows in diagram *A*, it will be seen that the polarity of groups 1, 3, 5, 7, 9 and 11 has been changed. The arrows of alternate groups now point alternate directions, thus making four salient poles. In following out these diagrams, and the others in this article, it might be well for those who are not entirely familiar with the method of checking diagrams with arrows to consult the articles in the September and October issues of INDUSTRIAL ENGINEER, which cover this subject. When changing this winding from the low-speed to the high-speed connection the number of coils or turns in series per phase is decreased by one-half. As the speed, however, is doubled the voltage at which the motor will operate will be the same. Likewise, the paths per phase have been increased from series to two-parallel, and therefore the current in the coils will remain the same. As a consequence, the torque will remain constant but the horsepower will be twice as great with the high speed as with the low speed.

Fig. 6—Controller for a four-speed motor.

This diagram is for the controller which is employed with the four-speed motor shown in Fig. 5. The drum segments are represented by the shaded squares and all of those squares which are in one of the large irregular blocks are connected together on the drum. The controller fingers are represented by the circles. As will be seen there are four forward speeds and four reverse speeds. The various connections which are made for the different speeds are shown in an accompanying table.



Two-Speed Winding With Constant Horsepower

In *D*, *E* and *F* is shown another type of two-speed winding, which in this case, has the same horsepower at both speeds. In this winding a two-parallel star connection is employed for the high speed, and a series-delta connection for the low speed. There are six leads going to the outside of the motor. Three of these leads have two connections, coming from different phases. These are leads L_1, L_2 and L_3. The delta connection as shown in *F* is for eight poles. As will be seen, a tap is brought out from the center of each phase of the delta connection. For the four-pole connection, as shown in *E*, these three taps are used for line leads and the three original line leads are tied together to form a star connection. This reverses groups 1, 3, 5, 7, 9 and 11. With this type of winding the same horsepower is obtained at both speeds, but the torques are different.

A motor which may be run at four different speeds by changing outside connections, and which develops the same horsepower at each speed is shown in the diagrams of Fig. 5. There are two windings on this stator, one winding designed to develop four and eight poles, and another winding for six and twelve poles, using the salient and consequent-pole arrangements.

In these windings a series-delta

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connection is used for the high-speed salient poles, and a two-parallel star connection is employed for the low-speed consequent poles. There are seven leads coming from each of the windings, but two of these are tied together inside the motor to form a common lead thus leaving only thirteen leads which are brought outside. No. 1 lead of each winding is connected to No. 1 lead of the other, inside the motor. Leads 13 and 17 form one corner of the delta of the four- and eight-pole winding. When it is in use these two leads are connected together, but when the other winding is in use the two leads are separated, thus opening the circuit while L_3 and L_7 on the six and twelve-pole winding are closed together. When either of the windings is not in use, it must be opened so that there will be no circulating current induced in it by transformer action. If each winding formed a closed circuit, then as only one winding is in use at a time, the active winding would induce a current in the inactive winding, which would prevent the operation of the motor. The coil pitch is 100 per cent, or full pitch, for each respective low-speed connection, and 50 per cent of full pitch for the high-speed connection.

Controller Employed with Four-Speed Motor

In Fig. 6 is shown a diagram of the drum-type controller employed with the four-speed motor shown in Fig. 5. This controller gives any one of four speeds in either the forward or the reverse direction, according to the position of the controller handle. The table shows the speeds and connections obtained when the controller drum is moved forward, for forward speeds.

When connecting up a four-speed, double-winding motor the windings are connected on opposite sides of the motor; therefore when picking up the groups of one winding in a clockwise direction, pick up the groups of the other winding in a counterclockwise direction. If this rule is not followed out the direction of rotation at all speeds will not be alike; that is, the direction of rotation at the 1 and 3 speeds will be opposite to that of the 2 and 4 speeds.

It is interesting to compare the type of winding shown in *D*, Fig. 4, with that shown in Fig. 5. In *E*, of Fig. 4, a two-parallel star connection is used to obtain a four-pole (salient) winding, while in Fig. 5, a two-parallel star connection is used to produce an eight-pole (consequent) winding. Likewise, comparing *F* of Fig. 4 with *B* of Fig. 5, we find again that in Fig. 4 the delta connection is used for eight consequent poles while in Fig. 5 the delta connection is used for four salient poles. A close study will show that in *F* of Fig. 4 there is a series of four groups, 1, 7, 10, and 4, with a tap between groups 7 and 10. In *B* of Fig. 5, this series of four groups is arranged 1, 7, 4, and 10, the last two groups being changed. This difference in connection is also true for the other two phases.

In conclusion it might be well to state that a thorough understanding of these diagrams cannot be had by merely reading this material through. If a knowledge of any kind of winding is to be obtained, it is advisable to draw out and check a large number of different diagrams, which will drill the subject well into mind and reveal many details that otherwise would remain unknown.

Connections and Speeds Obtained on Moving Controller Drum Forward*

Speed No.	Poles	Rev. per Min.		Kind of Connection	Connections			
		60 Cycles	25 Cycles		*Line 1	*Line 2	Line 3	Other Connections
1	12	600	250	2-parallel Star	4	5	6	1 to 7 to 3 to 2
2	8	900	375	2-parallel Star	14	15	16	1 to 17 to 13 to 12
3	6	1200	500	Series-Delta	1	2	3	7 to 3
4	4	1800	750	Series-Delta	1	12	13	17 to 13

*For reverse speeds, which are secured by a reverse movement of the drum, Line 1 and Line 2 are automatically interchanged, which reverses the direction of rotation. All other connections are identical with those shown for forward speeds.

Installation of Flexible Couplings

(*Continued from page 583*)

of carefulness in operation or installation. Second, operating conditions, including overloads, determine the size of the coupling. Third, if the coupling shows excessive wear the cause most probably lies elsewhere.

Because the coupling will take some punishment is no reason for neglect or carelessness. If it did not take punishment it would not serve its purpose as a safety link to protect the more expensive machines it connects. Excessive wear shows that something is wrong and the only preventative is to find the cause and remove it.

The next article of this series will take up the types of cut-off couplings and clutches and their application in industry together with operating conditions and other considerations which must be taken into account when specifying this type of equipment for various industrial uses.

Editor's Note: Special acknowledgment is made to John J. Serrell, Smith & Serrell, Newark, N. J., and to the following companies for their kind assistance in furnishing information, counsel and illustrations for this and the other articles which appear in this series: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; The Bartlett Hayward Co., Baltimore, Md.; Charles Bond Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; Brown Engineering Co., Reading, Pa.; The Carlyle Johnson Machine Co., Manchester, Conn.; Chicago Pulley & Shafting Co., Chicago, Ill.; Conway & Co., Cincinnati, Ohio; The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; I. H. Dexter Co., Goshen, N. Y.; Dodge Manufacturing Co., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; The Falk Corporation, Milwaukee, Wis.; General Electric Co., Schenectady, N. Y.; The Hanson Clutch & Machinery Co., Tiffin, Ohio; The Hill Clutch Co., Cleveland, Ohio; The Hilliard Clutch & Machinery Co., Elmira, N. Y.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Medart Co., St. Louis, Mo.; Mesta Machine Co., West Homestead, Pa.; R. D. Nuttall Co., Pittsburgh, Pa.; The Pusey & Jones Co., Wilmington, Del.; Reeves Pulley Co., Columbus, Ind.; R. H. & F. M. Roots Co., Connersville, Ind.; A. L. Schultz & Son, Chicago, Ill.; Smith & Serrell, Newark, N. J.; Thomas Flexible Coupling Co., Warren, Pa.; Weller Mfg. Co., Chicago, Ill.; Western Engineering & Mfg. Co., Chicago, Ill.; The Williams Foundry & Machine Co., Akron, Ohio; T. B. Wood's Sons Co., Chambersburg, Pa.

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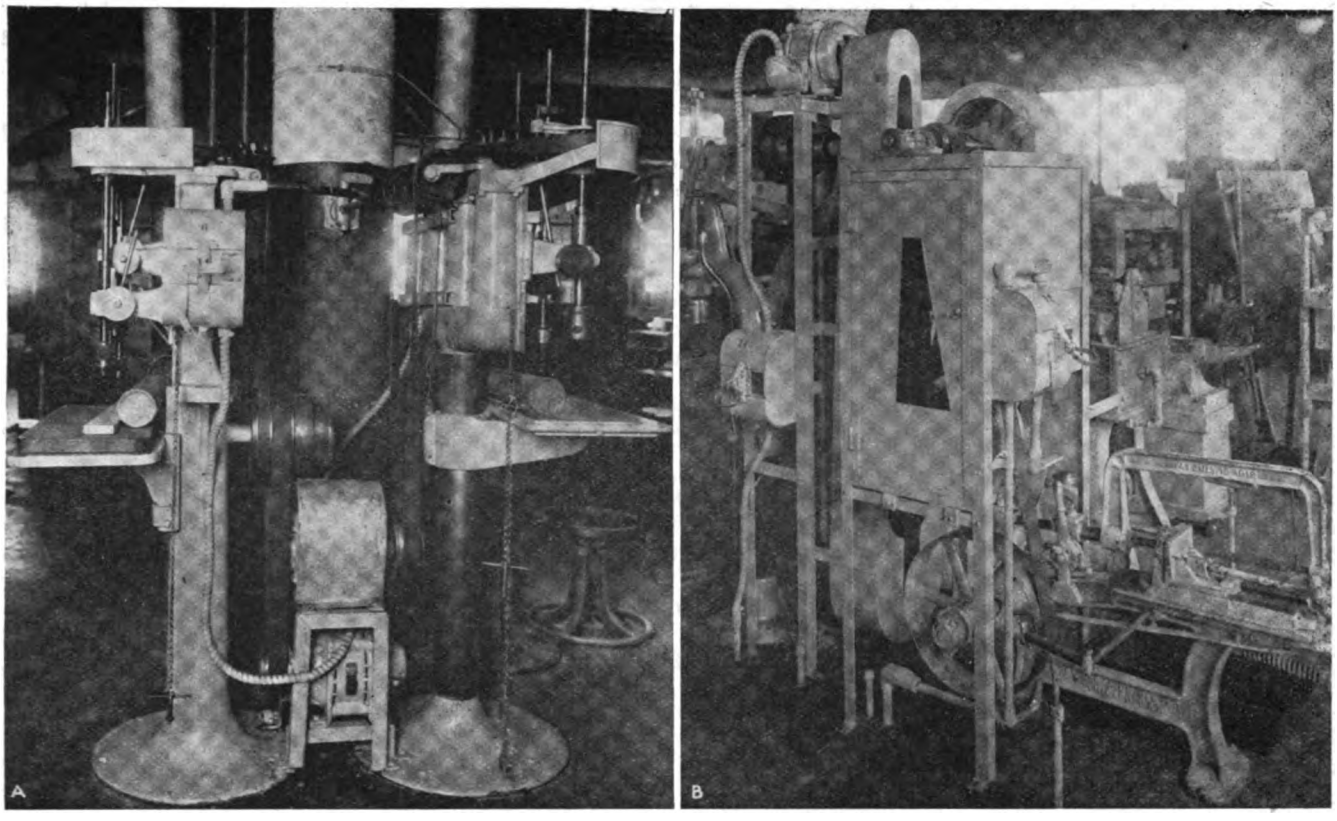


Fig. 1—Two places where the motors take up very little room.
At *A* is a two-story motor mounting. The motors are placed one above the other between the two drill presses which they drive. At *B* a power hack-saw and a boring mill are mounted back-to-back to save space. The motors are so arranged that they require the minimum amount of space. One of them is above the pulleys of the borer and the other is above the back part of the saw inside of a housing.

Some Practical Ways of

Mounting Small Motors

That Release Floor Space and Add to Safety, Ease of Operation and Control

By H. S. KNOWLTON
Contributing Editor, Boston, Mass.

FORMERLY the practice in many shops was to install electric motors anywhere within reach of the driven machines. As long as a tool would run it was a matter of more or less indifference where the motor was placed, so great was the convenience of electric service contrasted with the old mechanical drives. All this is changed today in shops where the tool and motor drive layouts are really planned. Some engineers have almost made a hobby of correct motor applications, and there is much good-natured rivalry now as to the quality of motor drives, especially from the standpoint of motor location, mounting, and control arrangement. A fine example of skillful application of motors in direct driving and individual powering of tools is to be found at the Boston, Mass., repair shops of the Western Electric Company, Inc. What these drives mean in space economy is readily apparent after a study of the accompanying illustrations.

Repairs of telephone exchange and substation apparatus, electrical appliance maintenance and miscellaneous work are done in these shops. Small motors rather than large units are, therefore, required and as the tools used are small in comparison with those found in heavy machine work, the space requirements are of particular interest. The relation between the space volumes required by motors and driven machines tends to increase as smaller motors and machines are used. This does not mean that motor locations and mountings are unimportant in large tools, but it does mean that with smaller tools much care must be taken to get the most out of the drive from the space-economy viewpoint. Safety for the operator and for passing workmen is very important; at the same time motors and control apparatus both need to be within easy access for inspection, for manipulation and for repairs.

Bracket supports for the motor, as in the illustration, Fig. 5, are convenient and compact. Here a 1-hp. motor drives an engine lathe by belting running from the motor pulley to the main driving pulley at the top of the picture. The frame carrying the machine pulley cone is also used to support the motor starting switch which is mounted directly over the chuck, convenient for the lathe operator. The frame is of angle iron 1½ by 1½ by 3/16 in. in size. Flexible armored conductor meets the feed requirements with safety and ruggedness. No ordinary accident seems likely to cut off the motor service. The motor bracket projects slightly beyond the edge of the lathe, but in relation to the size of the tool, the space occupied by the power unit is practically negligible. An entirely different arrangement

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for a lathe drive is shown in *A* of Fig. 4. Here the motor, a ¾-hp. unit, is mounted on a hinged bracket at the end of the lathe. Quick changes of belting on the pulley cones can be made by means of this arrangement, and the driving belt being inside, no extra protection is required. As shown, the starting switch is close to the operator's hands. The advantages of flexible conduit for short runs around corners is well shown here. This type of conduit is used extensively in the plant. Still another drive for a lathe is shown in *B* of Fig. 3. The machine at the right is a lathe on which the motor is mounted under the lathe head.

Two excellent examples of ways to save space are illustrated in Fig. 1. True Yankee ingenuity is shown in the "two-story" motor mounting in *A* of Fig. 1. Here two drill presses located on opposite sides of a column are separately driven by 1-hp. motors located one above the other on a common framing. One motor is inclosed by the framing and the other is located on top of it. Angle iron of 1½ in. by 1½ in. by 3/16 in. is also used here, and the framing is bolted into the drill-press bases between the two pedestals. This gives a very convenient and symmetrical arrangement. Both motors are fed from starting boxes mounted on the drill pedestals, with short runs of flexible metallic conduit from the boxes to the motors. A single outlet in the building column is utilized as a center from which to branch-feed the two starting boxes. Each tool is separately supplied and controlled, and yet the two are wired virtually as a unit, with advantages in the amount of material used and convenience of inspection and repairs.

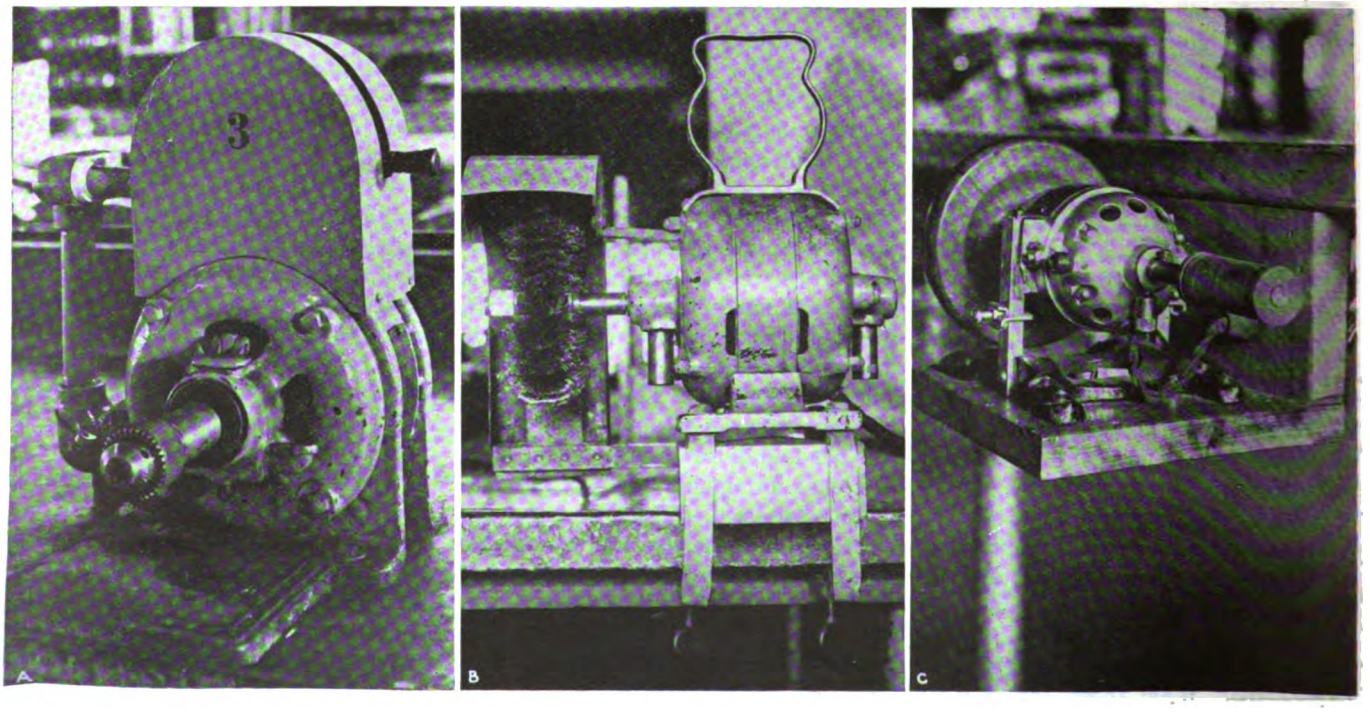
WITH THE increasing use of individual motor drive for machine tools, the problem of where and how to mount the motor and control equipment is of much importance. Any study of this problem must give due consideration to these factors: (1) Saving of floor space by mounting motor and control in out-of-the-way places. (2) Easy accessibility for inspection and repair. (3) Convenience of manipulation by operator. (4) Protection of operator and equipment from injury. This article shows how these factors are combined in mounting motors on machines in the Boston, Mass., repair shop of Western Electric Company, Inc.

In *B* of Fig. 1 a boring mill and power hacksaw are mounted back-to-back to save space around aisles, the two units being close together and individually driven by 1-hp. motors. The boring mill motor is mounted on top of a light angle-iron frame (1½ in. by 1½ in. by 3/16 in.) which incloses the driving belting and pulleys and forms a convenient mounting for the starting switch shown at the left. The hacksaw motor is even more out of the way, being located in a galvanized sheet-iron housing equipped with a hinged door giving immediate access to the motor. An angle-iron frame surrounds the driving pulleys and belting; thus the unit presents a smooth face to the aisle. The motor itself is mounted on two short horizontal straps fastened to the frame. A more compact belt-driven arrangement would be difficult to secure in this case. The bulkiness of the hacksaw itself is practically the only inconvenience which may be found with the installation.

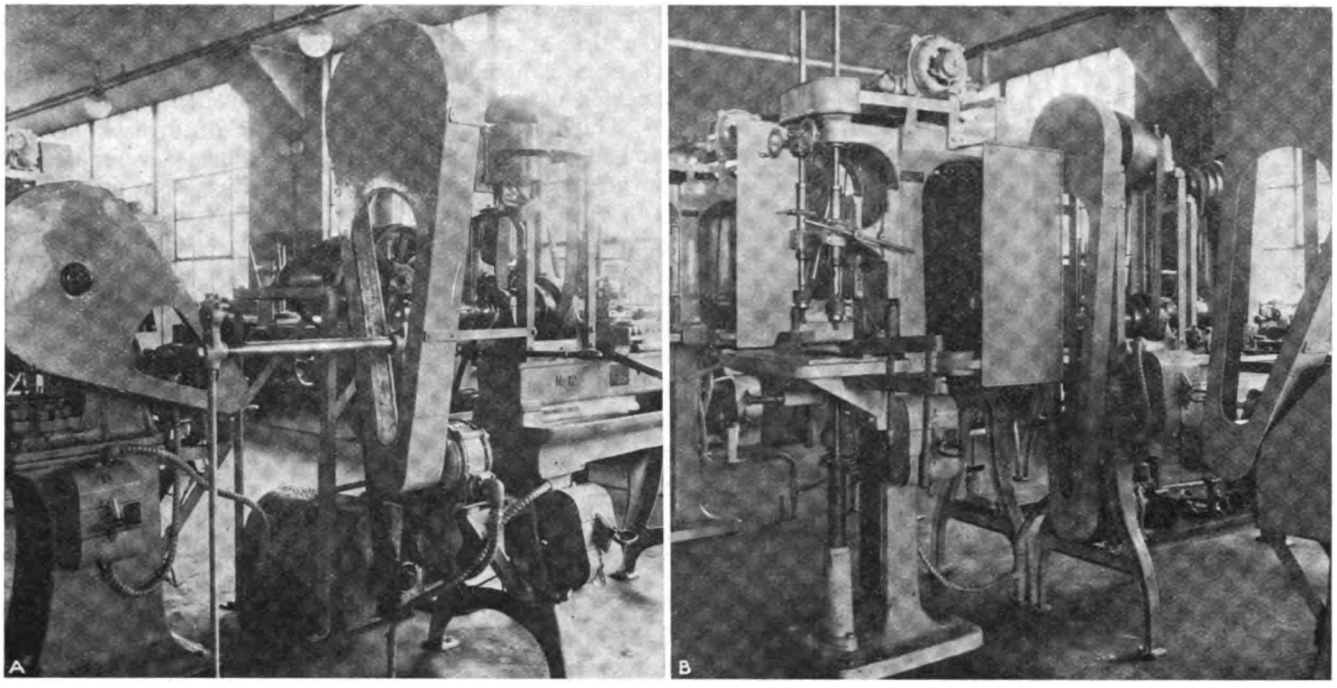
The punch-press and screw-machine drives shown in *A* of Fig. 3 required motor locations a few feet distant from the main shafts driven. The proper height of motor installation for the punch press (at left) was easily secured by mounting the motor on an angle-iron bracket at the rear of the frame.

Fig. 2—Screwdriving, polishing and coil-winding motors mounted at benches.

A motor-driven screw-and-bolt driver is shown at *A*. The reversing switch on top of the motor facilitates rapid handling of this light work, and rigid conduit feed gives protection to both operator and wiring. A portable polishing motor with detachable clamped straps for bench service is shown in *B*. Ruggedness and portability are well combined in this unit. At *C* there is shown a small motor for winding wire on spools, mounted on a right-angled wooden base and attached to a bench—a good mounting for small motors.



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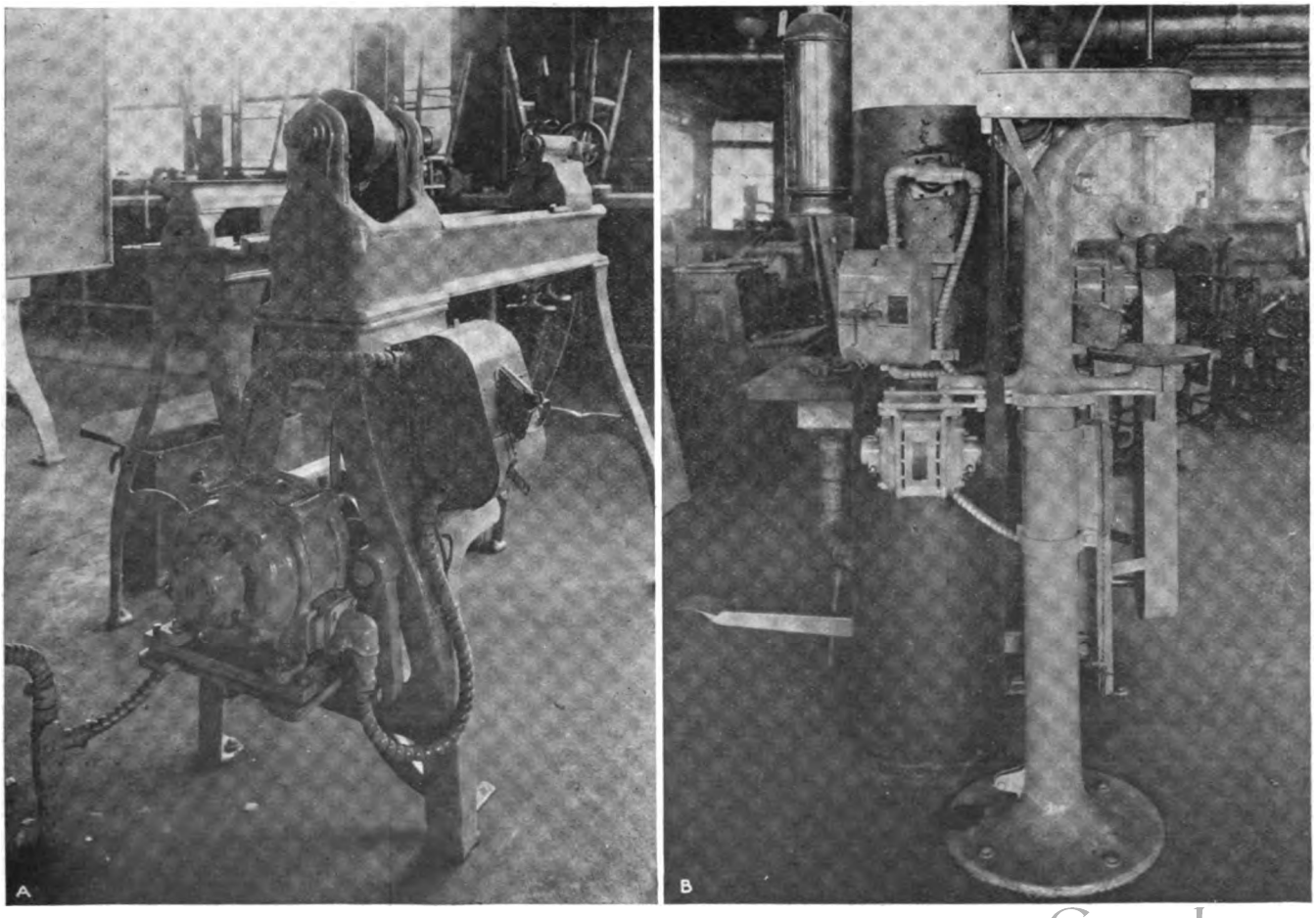
The starting switch was placed on the side of the machine pedestal close by the operator's position, with a metal guard above for protecting the hands and sleeves from the belt. The motor, rated at 1 hp., is placed on two 3-in. by 1½-in. by ¼-in. channels, mounted on a bracket of 1½-in. by 1½-in. by ¼-in. angles set against the machine pedestal at the back. (*Continued on page 611*)

Fig. 3—Angle-iron and strap-iron brackets on the machines hold these motors off the floor.

In *A* the motor on the punch press is supported by a bracket at the rear of the machine. The switch is convenient to the operator's right hand. At the right in *A* another bracket supports the motor at one end of the screw machine. The motor mounted above the multiple drill at the left of *B* is entirely out of the way. It rests on U-shaped straps bolted to the frame of the drill. The motor on the lathe at the right in *B* is under the lathe head. It is supported on the cross bracing between the two ends of the lathe. The advantages of flexible armored conductor in wiring short turns such as here are well illustrated. For other lathe mountings see the illustration at the beginning of this article and also *A* of Fig. 4.

Fig. 4—Compact switch and motor arrangement for a lathe and a drill press.

A bracket on the end of the lathe in *A* supports the motor. The pulley and belt are in a protected position underneath the lathe. The operator's hand can reach the switch without any effort. The motor on the drill press at *B* is suspended from a bracket fastened to the frame of the drill.



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INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, December, 1923

If You Follow Some One Else You'll Always Be B hind

WHILE scientists and inventors the world over were proving to their own satisfaction that it was impossible to make a heavier-than-air flying machine and, in view of previous failures, seemed to have all of the evidence on their side, the Wright brothers went ahead and made one. While other automobile manufacturers were making money building expensive cars, Henry Ford started to make a good but cheap car, and thereby laid the foundation for an unparalleled success.

Anyone can follow a crowd, but the men who have been the most successful, not alone in accumulating money but in making noteworthy advances in every line of endeavor, have in many instances been those who got out of the beaten paths and went their own way. Custom and precedents laid down by those who have gone before should be used as aids, not barriers, to progress.

We cannot all be great engineers or inventors or business men, but no matter what our job is, we can do our own thinking and investigating and at least attempt to devise better equipment and better ways of doing things, rather than follow blindly in someone else's footsteps.

One of the great dangers of following others too closely is that they may be going in the wrong direction.

This Is Entirely About You

NOT A WORD of what follows will deal with any detail of your job. What is said refers to YOU, in capital letters. But we are going to assume that you have had some years of experience in the maintenance of industrial equipment and know a whole lot about the ills, the accidents, the minor troubles and the failure of this equipment through neglect, abuse, carelessness and handling by the inexperienced.

You, yourself, are operating and maintaining a very delicate and sensitive mechanism. Yet in spite of what you may know about operation and maintenance unless you are very different from 95 out of every 100 such men, you neglect, abuse and operate this mechanism so that it cannot under any conditions give you the service it should over what is claimed to be its normal period of usefulness at greatest efficiency.

This mechanism has a number of direct-connected members. When one element is down for repairs the whole machine is shut down and its output stops. It's an investment that represents a profit or a loss depending upon how seldom or often it is shut down. This mechanism requires different attention in Winter than in Summer; it burns fuel and leaves a residue and its efficiency in utilizing this fuel varies more widely than that of a steam boiler and requires more attention. Like the boiler this mechanism has auxiliary control and regulation that gets out of order, and when neglected cannot be as quickly corrected or repaired.

You do not need to guess; this mechanism is you yourself—your brain, your stomach, your arms, your legs, feet and hands—the very means with which you earn your living and help to build the success of the institution or works with which you are associated. Do you know that of all industrial workers of the age of thirty-four, seventy-six per cent have some physical impairment or defect that minor medical, dental or surgical treatment or advice can correct and enable the human mechanism to perform its normal operations to the fullest in those years when experience and position secured will bring the largest personal reward?

As a plain business proposition you cannot afford to neglect or carelessly operate and maintain the human mechanism that is you, for on your good health and the exercise of your mental and physical being to the fullest, the developments and progress of this nation depend. If you agree with us that more attention should be paid to the mechanism referred to, then paste this page on your plant bulletin board for the benefit of your associates.

Regular Maintenance Vs. Night and Sunday Rushes

DURING the past two years INDUSTRIAL ENGINEER has presented numerous examples of how maintenance work is handled in different kinds of plants and the results that have been secured through avoiding preventable breakdowns and interruptions of production schedules. It is generally recognized in large plants that general maintenance work should be regarded as a prevention and not a cure for operating troubles. But it is not so generally recognized just how much attention and money can be spent in this prevention work, week-to-week and month-to-month, when things are apparently going all right and troubles are not in sight. It often takes a serious breakdown and regular Sunday rush work to indicate to plant managers that they pay for general maintenance some time and not only that—they lose a lot of production time when they adopt the policy of doing as little regular prevention work as possible and rushing repair work when it comes up.

No group of men in a large works knows more about the troubles with equipment than the men who are called upon to locate them, repair them and take the necessary steps to prevent repetitions of the trouble. When these men are given full responsibility for inspection, overhauling and repair work and this work is organized on a day-to-day routine basis, those troubles that grow from small to serious proportions can

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be caught and the remedy in many cases applied with the men engaged in production at machines hardly knowing that anything has happened, and so production goes on and the only charge that the trouble causes is that due to the maintenance time and material.

Maintenance work when well organized in a large plant will cost money or save money in terms of preventable losses in production exactly in proportion to the ability of the men in charge of the work, and the authority and responsibility that is given to them. When they are confined to a repair shop and answer miscellaneous trouble calls through the works they are working at their lowest efficiency and are "fixers" in every sense of the word. A maintenance organization can only secure the results it should when headed by one or more men who know thoroughly the production problems in the plant, the times when rush work must be rushed, the times when materials or machine setups are changed in such a way as to impose a greater or less load on the power circuit and hundreds of other things that constantly change in a production program. These men can then set up inspection schedules, and select times for doing repairs and overhauling so as to fit into the production program at the right point and prevent an interference with it at any other time. Where maintenance work has been placed upon a regular schedule the Sunday rushes are talked about as things that used to be.

Electric Power Apparatus Standards

IN LARGE industrial works standardization of electrical apparatus subject to rough and careless treatment is a matter that is receiving more and more attention from two standpoints: Reduction of stock inventory of parts and miscellaneous fittings needed for repairs; second, ability to carry duplicate and interchangeable units that can be quickly installed in case of service interruptions through failures. At the last meeting of the Association of Iron and Steel Electrical Engineers this matter came up for discussion and it was urged that the holes for the holding bolts of motor frames be spaced in a uniform manner. This is only one of many apparently simple matters that pile up a considerable but unavoidable maintenance cost when non-uniform designs of equipment are in use.

In this problem of standardization the electrical apparatus manufacturers represented by the Electric Power Club have made marked headway. A new edition of their Standards has just been issued and should be secured by every industrial man who has the responsibility for the installation and replacement of electrical equipment. This book gives details of adopted standards and recommended practice not only for motors and generators, but for transformers, mining and industrial locomotives, electric tools, industrial control apparatus, switchboards, circuit breakers and storage batteries and refers to auxiliary mechanical devices such as pulleys, belt and gear drives, shaft extensions and the like.

In view of the agreement on these standards by companies manufacturing more than ninety per cent of the electric power and control apparatus used in this country and the thinking that has preceded their adoption, operators and maintenance men will find the new edition of standards a handy and proper source of information when laying out or checking up on suggested standardization in their plants. A copy of Standards of the Electric Power Club can be secured by writing the Executive Secretary, Keith Building, Cleveland, Ohio.

Look Ahead But Don't Forget to Watch Behind

MANY MEN in industrial positions are frequently disappointed, when promotions are made, to find that someone else has been put into a coveted position when they feel themselves as well or perhaps better qualified. The tendency, often, is to attribute such a selection to "pull" or "drag," which may be the real reason in some instances. However, it usually pays for the man who is left out to make a thorough accounting of himself and his qualifications and strengthen those points which are weak so that he will be able to qualify above all competitors at the next opening.

One point which many men neglect to consider and which the top executive practically always asks is, "How will we fill the place of the man promoted? Has he anyone trained ready to step into his shoes?" If not, even though the man is well qualified otherwise, but few executives will risk disrupting the department operating smoothly and effectively by taking away its head if there is a prospect of getting another man whose promotion will bring forward a substitute ably trained to carry on the old job.

The best place to train men is on the job. This, however, does not exclude the taking of advantage and using additional information supplied by books, magazines, night schools and correspondence courses. It usually works best when both practical and theoretical training are given together. Frequently, men do not impart information to their subordinates because of a fear of letting out the so-called "secrets." Promotions, however, seldom come to those not ready; it comes to those who look forward and watch behind.

Beware of Temporary Installations!

IN ORDER to meet emergency conditions which are presumably of short duration, or a suddenly-increased demand for power service when new departments are added, so-called temporary power circuits are often installed. The intention is, of course, to replace them in a short time with installations of a more permanent character, but in many instances these makeshift additions to the original installation are allowed to remain.

Temporary work is seldom laid out and installed with the same care that is given to a permanent installation and the final result is likely to be a distribution system which is, on the whole, cumbersome, probably inadequate and oftentimes hazardous from operating and safety standpoints. When temporary installations are put in, it is easy to overlook some of the refinements which do much to insure maximum safety to operators and machines, at a cost which is small in comparison with the benefits obtained.

Emergency demands and conditions cannot always be foreseen, but a little thinking will usually show where increased demands for power service are most likely to arise, in plenty of time to provide well-planned and carefully-installed power service extensions.

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Charles Proteus Steinmetz

The man and his career as related after his death on Oct. 26 by E. W. Rice, Honorary Chairman of the Board of the General Electric Company.



Dr. Steinmetz in a characteristic pose at work in his own study.

"THIRTY YEARS ago I first met Steinmetz. The occasion was as follows: The General Electric Company had been recently formed by the union of the Edison Company and the Thomson-Houston Company, which brought into one enterprise the results of the work of Edison, Elihu Thomson and many other early pioneers in the fields of arc and incandescent lighting, electric traction and industrial motor application.

"Rudolph Eichmeyer of Yonkers, N. Y., had developed some interesting designs for electric traction purposes, and certain novel and economical forms of windings for armatures of electrical machines. I was then in charge of the manufacturing and engineering of our company and my views were sought as to the desirability of acquiring Eichmeyer's work. I remember giving hearty approval, with the understanding that we should thereby secure the services for our company of a young engineer named Steinmetz. I had read articles by him which impressed me with his originality and intellectual power, and believed that he would prove a valuable addition to our engineering force.

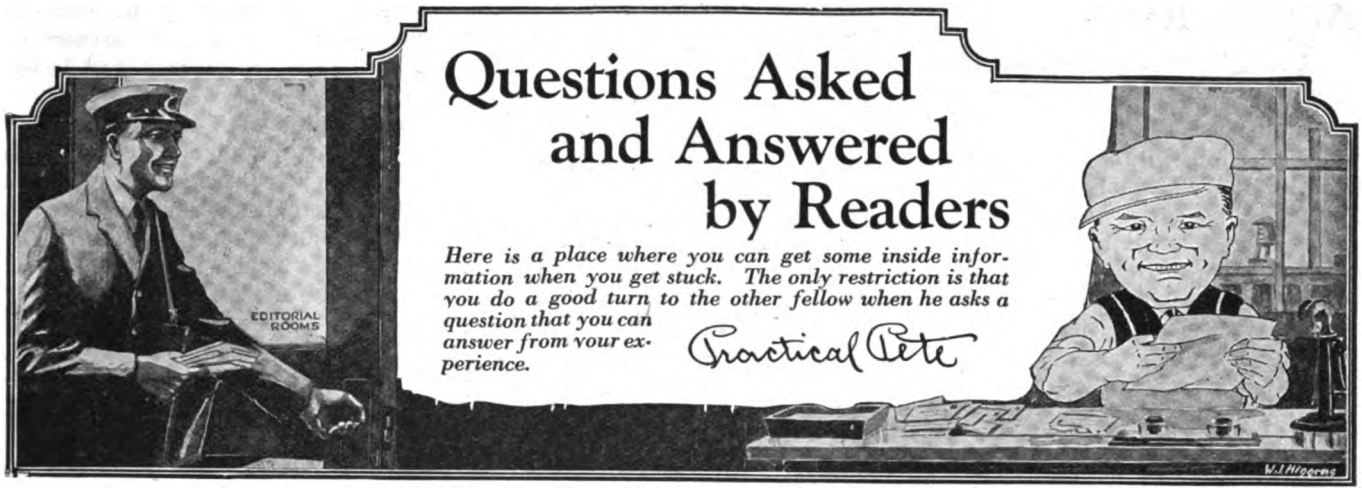
"I shall never forget our first meeting at Eichmeyer's workshop in Yonkers. I was startled, and somewhat disappointed by the strange sight of a small, frail body surmounted by a large head, with long hair hanging to the shoulders, clothed in an old cardigan jacket, cigar in mouth, sitting crosslegged on a laboratory work table. My disappointment was but momentary and completely disappeared the moment he began to talk. I instantly felt the strange power of his piercing but kindly eyes, and as he continued his enthusiasm, his earnestness, his clear conceptions and marvelous grasp of engineering problems convinced me that we had indeed made a great find. It needed no prophetic insight to realize that here was a great man: one who spoke with the authority of accurate and profound knowledge and one who, if given the opportunity, was destined to render great service to our industry. I was delighted when, without a moment's hesitation, he accepted my suggestion that he come with us.

"Steinmetz had already made his first important contribution to electrical science in investigations of magnetism, and especially in formulating and determining the laws governing the losses in iron subjected to varying magnetic induction. He showed that the hysteresis varied as the 1.6 power of the density of magnetic flux. This made possible for the first time the exact predetermination of the so-called iron losses in the armatures of electric motors and generators and in the transformers and other electrical apparatus employing iron. As a result, the quality of our electrical machinery was improved, and the weight and costs reduced. It is difficult at this date to realize the fundamental importance of this one contribution to the orderly and definite progress of the electrical industry.

"During the first decade of the commercial application of electricity to light and power, which may be said to cover the period between 1880 and 1890, direct current only was used. This was the basis of the Edison system, the Thomson-Houston arc system, and the Vanderpoel and Sprague railway motor systems. The laws governing the flow of direct current were simple and easily understood, and could be treated by mathematics of the most elementary character.

"About the time Steinmetz came with the General Electric Company in 1893, the use of alternating current for lighting, power, and other purposes was just beginning to be of demonstrated commercial value. Advance in the commercial use of alternating current was hindered by the extreme difficulty of understanding the technical nature of its action and of the various phenomena connected therewith. * * * Steinmetz took hold of this situation with characteristic energy, and soon brought order out of chaos. He abolished the mystery and obscurity surrounding a. c. apparatus and soon taught our engineers how to design such machines with as much ease and certainty as those employing the old familiar direct current. * * * It was fortunate indeed for our company and for the electrical industry that Steinmetz became associated with us at the critical time when the alternating current development had just started. It is not too much to say that his genius and creative ability, not only in his own personal work, but in advocating and obtaining the general use of a simple mathematical system for treatment of a. c. problems, was largely responsible for the rapid progress made in the commercial (*Continued on page 612*)

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Who Can Answer These?

Determining Charging Rate for Storage Battery—Can any of the readers of INDUSTRIAL ENGINEER tell me how to find out from a storage battery at what amperage it should be charged?
Temiskaming, Que., Can. J. H. F.

* * * *

Equalizing Large Generators—I should like to have some reader of INDUSTRIAL ENGINEER tell me how to go about equalizing two 112-kw., 250-volt d. c. engine-driven generators and two rotary converters which furnish power at the same voltage. One of the converters is rated at 150 kw. and the other at 300 kw. They are supplied with alternating current from a public utility company and are modern units of up-to-date design. The engine-driven units are old-type, four-pole machines. I should like to equalize these units by means of resistance shunted across the series field. What losses would be incurred by this method of operation? How should the proper value of the resistance be determined?
Cincinnati, Ohio. R. G. P.

* * * *

What Causes this Magnet Switch to Stick?—We have on a crane hoist a 440-volt a.c. magnetic limit switch which fails to open about one-half of the time when the current is taken off the magnet coil. Although the core is laminated, there is apparently enough magnetism left to hold the switch in. All of the working parts are clean and free. Will someone kindly suggest a remedy for this trouble?
Selby, Calif. J. T. C.

* * * *

Trouble with Portable Electric Drill—I have been having trouble with a Westinghouse, ⅜-in., portable drill. This drill operated satisfactorily for two years and then began running at only half speed. Occasionally it would start off on normal speed, but soon drop back to half speed. I rewound the stator and when this did not clear the trouble I rewound the armature, with no better results. Instead of winding the armature on a form I wound it by hand. So far, I have not been able to get it to run at normal speed.

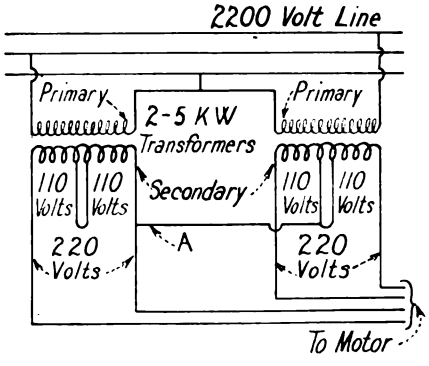
Another portable drill, a Van Dorn, came in recently with the armature roasted. I wound this armature by hand and it, too, ran at half speed. I rewound the armature again, this time on a form but so far have not been able to get it up to full speed although the field coils have been tested out and seem to be all right. The armature core number of the Westinghouse drill is 12-A-876; the Van Dorn armature coil number is Code 8406. Both drills are designed to operate on 110-volt alternating current. I shall appreciate it very much if some reader can tell me what is the matter with these drills.
Philadelphia, Pa. R. I. G.

* * * *

Method of Soldering Leads to Commutator Bars—Can any of the readers of INDUSTRIAL ENGINEER give me the following information: (1) The design of a transformer for soldering the leads to the commutator risers with the aid of carbon electrodes. (2) I have done armature winding on large machines, but would like to know the best way of soldering leads to commutators of fractional horsepower motors, such as fans. I should like to know the type of soldering iron to use, and other information that will help me to save time.
San Francisco, Calif. S. H. S.

* * * *

Trouble in Operating Two-phase Arc Welder Set on Three-phase Circuit—I had occasion recently to operate a two-phase, four-wire, 220-volt, 60-cycle, 1,800 r.p.m. 5-hp. Lincoln motor, which is direct connected to a Lincoln welding generator, on a three-phase, 2,200-volt, 60-cycle circuit. The transformer connection shown was tried. I found that the motor would start but in a short time would get very hot. The wire at *A* was cut and then the motor did not heat so much, so that by stopping the machine about every hour and letting it cool off I was able to do the welding, but too much time was lost. I wish some of the readers of INDUSTRIAL ENGINEER would tell me if this connection is correct and if so, what causes the motor to heat.
Tyrone, Pa. H. L. F.



* * * *

Trouble with Commutator Grinding Machine—I recently ground a commutator on a 150-kw. generator with one of the finest tools made, manufactured by the Jordan Commutator Grinding Company, but I did not have much success owing to the rapid wear of the corundum wheel.

When I set the wheel against the commutator it cut a groove, due to the rapid wear of the wheel. Before I could move it an inch along the face with the lead screw the wheel was worn so badly that it would barely touch the commutator. I tried setting it up for very light cuts and turning the lead screw rapidly but that did not help any and it is not a first-class job. The commutator is 14 in., in diameter, 12 in. long and turns at 1,200 r.p.m. The corundum wheel turns at 2,880 r.p.m., cutting against the direction of rotation of the commutator, is ½ in. thick and was 8 in., in diameter at first but when the job was finished it was only 5 in., in diameter.

I should like to know if this trouble is commonly experienced.
New Orleans, La. P. B. A.

* * * *

Correcting Power Factor by Synchronous Condenser—I wish to submit the following problem to our readers: *A* is a distributing station supplying power to four feeders, *B*, *C*, *D* and *E*; *B* takes 4,000 kw., *C*, 3,500 kw., *D*, 3,000 kw., and *E*, 2,000 kw. The power factor of these loads is: *B*, 80 per cent, *C*, 78 per cent, *D*, 75 per cent and *E*, 72 per cent, all lagging. It is desired to install a synchronous condenser at station *C*, to give 95 per cent power factor. Would it make any difference in the size of condenser required at *C* if stations *B*, *D* and *E* were to correct their power factor to unity instead of running at 80, 75 and 72 per cent respectively, as at present, (1) in case station *A* has ample generator and exciter capacity and (2) in case this capacity is just enough to carry the load?
Belleville, Ont., Can. J. H. G.

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Answers Received To Questions Asked

I noticed in the November issue of INDUSTRIAL ENGINEER that Edward A. Gibbs in answering a question by V. W. M. makes a statement about ground wires which is not entirely correct, and thinking that he is misinformed I write to correct the statement.

He says that in cities outside of Boston only one ground wire is needed at a service entrance to a building. This is not so in Everett, Mass., where two are required.

Our method of grounding is to use two No. 8 ground wires, one for the service wire ground and one for the service conduit ground. We do allow a piece of ½-in. conduit to be run from the service switch to the point of attachment to the water pipe. This conduit is to contain one No. 8 wire which is used to ground the service. The conduit is then bonded to water pipe with a separate piece of No. 8 wire and forms a second ground for a service conduit and main switch cabinet. In any case two separate ground clamps must be used on water pipe.

These grounds need not be run back of water shut-off unless the equipment is the only one on the transformer, in which case they must.

I would add that service conduit which is insulated from other metal work in building and is so located that it is out of reach of anyone on the ground or other grounded metal work is not required to be grounded.

PERCY A. BLAISDELL.

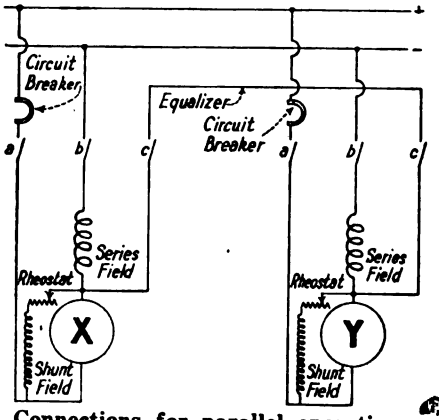
Inspector of Wires,
Everett, Mass.

* * * *

Operating Two Direct-Current Generators in Parallel—We have in our plant two 300-kw. d. c. generators. These machines are wound series compound, are equipped with equalizers and are connected in parallel. They are in continuous operation, except that once in 24 hours they are shut down for about 10 minutes for cleaning. We leave the resistance on the shunt field in the same position as when running, as there is no load on the machine. We trip the breakers and pull the equalizing switches out. I should like to know, however, if the machine is likely to be damaged in starting up again in case the engineer should shut down with the resistance fully cut in on the shunt field and both breakers tripped, but with the equalizing switches in. The running voltage of this machine is 250 volts. When starting up with the resistance cut in the machine does not build up the voltage. I should like to know what voltage the incoming machine would build up with the shunt resistance cut fully and receiving its only excitation from the other machine through the equalizer.

St. Louis, Mo. F. G.

Referring to a question by F. G. in a recent issue of INDUSTRIAL ENGINEER, on the parallel operation of two compound-wound, direct-current generators, the accompanying sketch shows the usual connections for the operation of such generators in parallel. For large machines three separate switches are generally used at *a*, *b* and *c*. On smaller machines switches *b* and *c* are sometimes combined to form a double-pole switch, although in most cases they are all combined in a triple-pole switch. In some cases where the machines are at a considerable distance from the main bus, the equalizer is often run straight between the machines and the switch eliminated.



Connections for parallel operation of two compound-wound direct-current generators.

Assuming that generator *X* is running and it is desired to start up *Y* it will be necessary first to bring the machine up to speed with switches *a*, *b* and *c* open. If we now close the equalizer switch *c* nothing will happen, as no closed circuit will be formed. If in addition we close switch *b*, a circuit will be formed through the series winding of machine *Y*. The result will be a lowering of the voltage in machine *X*, due to the fact that the excitation of this machine is now less because the load current which was formerly all going through the series field of machine *X* is now divided between the series fields of both machines, in inverse proportion to their respective resistance. The shunt rheostat of machine *Y* must now be adjusted to bring the voltage up to that of the bus to which the machine is to be connected. After closing the circuit breaker switch *a* is closed, thus putting the machine in service. To make the machine take its share of the load the shunt excitation is still further increased until the desired load is being carried.

The advantage of having the three switches *a*, *b* and *c* combined into one triple-pole switch, is that less voltage disturbance is caused to the machine already in service. The voltage of machine *Y* is brought up to that of the bus by means of the shunt rheostat. The three switches are then simultaneously thrown in and the series field excitation on the incoming machine causes it immediately to take some of the load, thus making up for the voltage drop in machine *X*, due to the lower series field excitation.

In starting the two machines up from standstill it is evident that no harm could be done by having the equalizer switches *c-c*, of both machines closed. Switch *b* of both machines could also be closed without causing any current whatever to flow in the series fields. As soon, however, as the circuit breaker and switch *a* of either machine are thrown in, a circuit is set up between the positive bus, through the armature of the machine connected, and through the series fields in parallel to the negative bus. The voltage will depend upon the adjustment of the shunt rheostat of the machine connected and the excitation caused by the series fields will depend entirely upon the load.

With switches *b* and *c* closed the voltage of an incoming machine would not build up very much if the shunt resistance is cut fully even if the load on the machine in service were heavy, causing maximum current through the series fields, because the series fields are usually designed to vary the normal voltage by only a relatively small percentage of the total. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

* * * *

In reply to the question by F. G. in a recent issue, if the two machines are connected standard the shunt fields are energized by taps taken between the brushes and the circuit breakers. The equalizers are usually connected directly to one brush lead. With both legs of a double-pole circuit breaker open on each machine there is no way in which current can flow to cause damage. If on the other hand single-pole breakers are used and improperly connected the closing of the equalizer would cause a practical

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short circuit that would open the breakers. If F. G. will put down on paper a diagram of the connections of the two machines he can easily see what will happen by tracing out the possible current paths when the breakers are open or closed, or the equalizer is open or closed, and so on. If he has a closed circuit and a live machine, current will flow. If his current cannot come through, then no shorts will occur.

Seattle, Wash. W. M. PRICE.

* * * *

Voltage from Transformers Connected in Different Ways—I should like to get an expression from readers of INDUSTRIAL ENGINEER as to their experience in connecting transformers open delta, closed delta and star. Please show, if possible, a sketch covering each of these connections and the voltages at 2,300, 1,100 and 440 volts. Perhaps someone can tell me where I can purchase a book which covers such subjects.

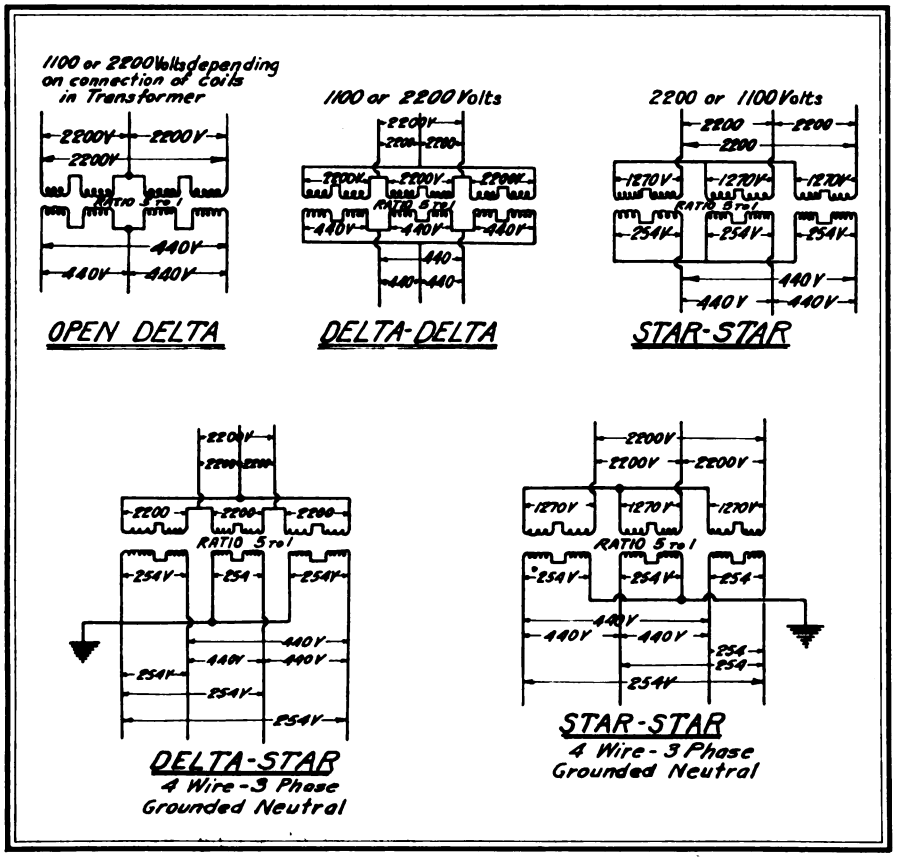
St. Louis, Mo. F. W. Mc.

Replying to F. W. Mc., who asks in a late issue about transformer connections, I hope the following information will be of some use.

The current and voltage in an open delta connection are 30 deg. out of phase with each other, resulting in an internal power factor of 86.6 per cent. The ratio of the energy delivered to the energy supplied is, 1 to 1.15. For this reason the open delta should be used in emergency only. Standard transformers of similar characteristics can be used and the primary and secondary voltages will be normal.

Delta-delta is probably the most frequently used connection for low-voltage distribution. The pressure across each transformer is the same as that on the line and any three transformers of like characteristics can be used. The total current in a delta bank will be 1.73 times the full load current of any one transformer. The secondary voltages will be the rated voltages of the transformers. This connection eliminates the third harmonic voltage from the line, as the magnetizing currents which cause it are circulated through the deltas. However, before installing a delta bank it is well to consider some of the disadvantages incident to its use: (1) A short circuit across any one unit constitutes a phase-to-phase short circuit and will impose heavy stresses on all of the windings. (2) If any one line becomes grounded the voltage stress in the other members of the circuit is raised to 1.73 times normal. (3) Large circulating currents can be set up in a delta-connected bank by slight differences of ratio and impedance in the individual units.

Various methods of connecting transformers in primary and secondary sides, with the voltages obtained.



The star-star connection is not used very much for distribution work as transformers wound for 58 per cent of the phase voltage must be used. To insure stability and suppression of the third harmonic voltage especially designed transformers should be used with the star connection. The four-wire, three-phase, delta-star connection is one which is coming into general use in late years. It is particularly well suited to grounded-neutral, low-voltage distribution systems. The primary may be star or delta, as conditions indicate. The secondary must be star. If a star primary is used the winding is rated at 57.7 per cent of the line voltage. If delta, the primary rating equals the normal line voltage. The secondary voltage is 1.73 times the rating of the individual unit and the voltage of any one phase wire to the neutral is 57.7 per cent of the voltage between phases. This system when connected delta primary, star secondary, combines the advantages of both methods of connection without a good many of the disadvantages of both of them. D. F. O'DONNELL.

Chicago, Ill.

* * * *

In answer to the question by F. W. Mc. in a recent issue regarding books which cover transformer connections, I would recommend a book entitled "Wiring Diagrams of Electrical Apparatus and Installations." This book, which will illustrate and explain just what he wants to know about transformer and many other connections in which he may be interested, can be obtained from the McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City. GEORGE ZEHNACKER.

Haledon, N. J.

* * * *

In reply to the question asked by F. W. Mc. in a late issue regarding various transformer connections, the most commonly used methods of connecting transformers on three-phase systems are: delta-delta, star-star, star-delta, delta-star.

When transformers are connected delta on both primary and secondary sides the secondary voltage will, with a 10-to-1 ratio transformer, be 1/10 of the primary voltage or, using primary voltages of 2,300, 1,100 or 440, the secondary voltages will be 230, 110 or 44 volts respectively.

Using the delta-star connection the secondary voltages will be 1.73 times the value for the delta connection, or 398, 190 and 76 volts respectively.

With a star-delta connection the

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secondary voltage is 57.7 per cent of what it would be with the delta connection or 133, 62 or 25 volts approximately.

The V, or open delta connection is generally used only for comparatively small loads or in case of damage to one unit of a bank. Since the line current passes through each transformer, the rating of each should be 0.577 of the total kva. of the load.

Detroit, Mich. JOHN B. RAKOSKE.

* * * *

Rewinding Motor for Four Speeds—We have a 5-hp., 1800 r.p.m., 220-volt, 3-phase, 60-cycle induction motor which has 48 slots in stator and is wound with 24 coils made of 13 turns of No. 15 wire. This motor is now connected single star. There is room in the stator for another winding due to there now being only one coil in each slot. There are 55 bars in the rotor. Short circuiting rings are ½ in. square, laminations 3¾ in. wide.

We would like to know if it is possible to rewind this motor with two sets of winding and secure four speeds: 600, 900, 1200 and 1800. The horsepower required at slow speed is about one.

Logan, W. Va. B. S.

In answer to the question of B. S., the four-pole winding must be wound in the stator first, and have 25 turns per coil of No. 19 magnet wire with a coil pitch of 1 and 7 and group 4 coils in series (the same as any four-pole machine). The six-pole winding is next wound in the stator with 34 turns per coil of No. 19 magnet wire with a coil pitch of 1 and 5. The groups are the same as any six-pole, 48-slot stator with an odd grouping of 3-3-3, 3-2-3, 2-3-2, 3-3-3, 3-2-3, 2-3-2.

This winding will give you approximately 1 hp. at the lowest speed and approximately 4 hp. at the highest speed. In other words, your motor will be a constant torque motor.

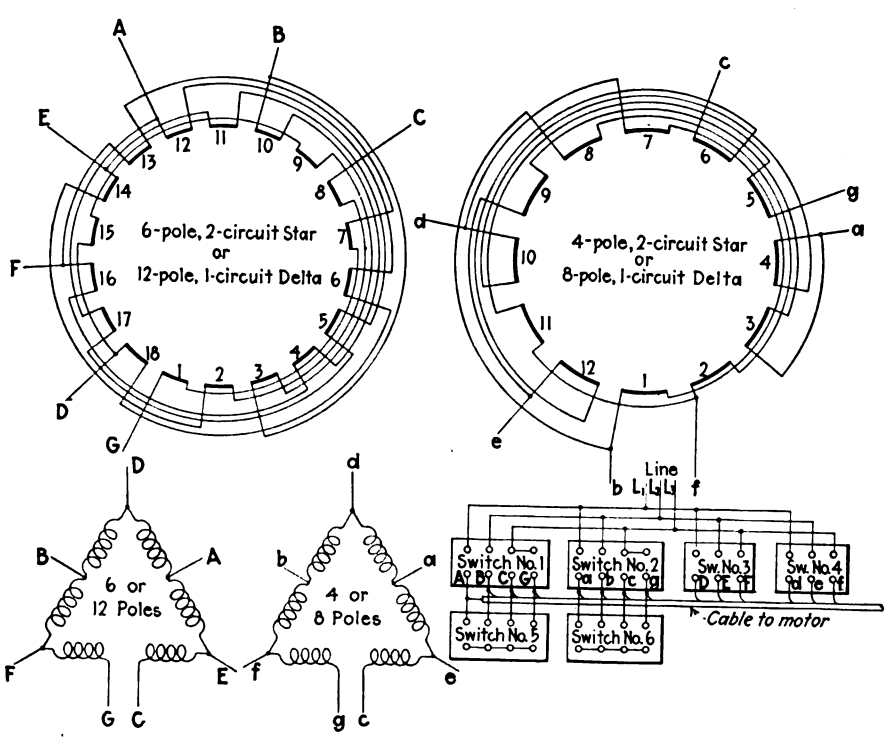
I am giving a set of motor connections and switch connections to show how to connect up the machine to the line without any trouble. If you happen to have a controller I can also send you a controller print. I infer that you are not using a controller so I am not including the connections.

You will have to use two, three-pole switches and four, four-pole switches of 30-amp. rating. I have twelve such machines operating with switches and four machines with controllers. The machines using switches must have more highly skilled men to operate them.

All motor leads must be numbered when the machine is being connected up by the winder in order to avoid trouble when the machine is completed. I might also add that if it is possible to use No. 18 B. & S. gage magnet wire in the machine, I would do so, as it will give you better starting torque under full load conditions.

Superintendent, Elliott Electric Co., Shreveport, La. GUSTIN R. LIEBER.

Diagrams for four-speed constant torque motor winding and the necessary switch connections for different speeds.



Changing Two-Phase Motors to Three-Phase—In our plant we have sixteen motors ranging from 3 hp. to 50 hp., making a total of 210 hp. These motors are wound with four to eight poles. We are considering putting in additional equipment and I shall appreciate it if some reader will answer these questions: (1) Would it pay to change over to a 3-phase system? (2) What saving would there be, if any, in power consumption? (3) Would it be necessary to rewind these motors to change them from 2-phase to 3-phase? (4) Would such a change increase the efficiency of the motors?

Jeannette, Pa. A. W. G.

With reference to A. W. G.'s question in a recent issue, if the additional equipment will be 50 per cent or more of the present equipment, it is likely that it would be better to make the change as eventually there will be little two-phase current available. Then it will be difficult for him to obtain other than special motors. I doubt if the question of efficiency would be worth considering as the three-phase equipment is usually only a very few per cent more efficient than the two-phase.

The procedure involved in changing the motors from two-phase to three-phase will have to be determined by the machines in question. Some manufacturers insulate each coil so that the two-phase grouping can be broken without danger. Others insulate groups only and when a group is broken there would be a chance of a breakdown. The first type of winding can be reconnected and makes a fairly satisfactory motor. Its efficiency would likely be improved but its capacity would be lowered by at least 15 per cent.

The only safe way to use the second type of winding is to bring out the center of one of the phases and connect the end of the other phase to it, leaving three leads for line use. This reduces the power of the motor by 10 to 15 per cent but we have a number of these in service and they have given no trouble. The last method of changing is to rewind, and there is no question that this will make a motor which is more efficient by 2 to 5 per cent. The old compensators can be used, provided that the voltage has not been changed, by running them open delta. In other words, take the twelve-lead starters and tie each pair of the middle six leads, thereby making a nine-lead starter.

The advantages gained in changing would be a slightly greater efficiency, standardization of equipment, lowering of wiring, motor and com-

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pensator cost, and a probable reduction in the number of burnouts owing to the elimination of one fuse and a double circuit.

Seattle, Wash. W. M. PRICE.

* * * *

Trouble with Control Equipment of Slip-Ring Motor—I wish some of the readers of INDUSTRIAL ENGINEER would answer the following questions: (1) I have to take care of two 20-hp. slip-ring motors which are controlled by rheostats and magnetic switches. I am now having trouble due to burning of contacts on the rheostats. About half of the segment contacts, counting from the starting position, are affected. The brushes seem to make good contact on the rheostats. This equipment is in use in a stone quarry. Could excessive dust be the cause of this trouble? (2) What is the best equipment to use for testing motors up to 30 hp. for grounds, shorts and so on? (3) I have a 5-amp., 3-cell, vibrator-type battery charger, operating at 110 volts, 60 cycles, which is very noisy. Can this type of charger be silenced to any extent?

Intercourse, Pa. M. A. D.

In the September issue, M. A. D. reports a case of trouble with the control equipment of a slip-ring motor. In answer to his question I should like to inform him that excessive dust or foreign material is no doubt causing the trouble described.

Frequent cleaning of the switch parts would keep burning of contacts down to a minimum. As is the case with most starters where there is much foreign matter in the air, it is a great advantage to have as few switch parts as possible. This has been accomplished in the enclosed, graphite compression type control. With this particular type of control the only switch parts used are the line contactors and the contacts which short circuit the resistance in the full speed position. All intermediate step contacts have been eliminated.

I trust that this information may be helpful to M. A. D.

W. F. PFEIFER.

Assistant Chief Engineer,
Allen-Bradley Company,
Milwaukee, Wis.

* * * *

I would suggest that M. A. D., whose questions appeared in the September issue, (1) respace his resistors so that he has a lower resistance in the sections that are burnt and higher resistance in those sections that are not burnt. The burning is caused by sparking. Sparking increases with the voltage, and while this method will not clear it entirely it will help, without the need of any new equipment.

(2) Shorts will take care of themselves and show up very quickly in the way of hot coils in the stator or sticky spots that will prevent the rotor starting when under live poles. I use line voltage through lamp resistance to test for grounds. A ground that will not spark will not make trouble immediately, if at all. A full ground will show up with a bright lamp.

(3) Placing the vibrator on a non-resonant base is about all that it is possible to do in the way of deadening the noise. W. M. PRICE.

Seattle, Wash.

* * * *

Explosion of Totally-Inclosed Motor—I should like to know if any readers have had accidents similar to the following: The stator of a totally-inclosed, split-phase, ½-hp. motor was rewound and after assembly was given an hour's running test. It was then shut down to see how the starting torque compared with a motor of a different manufacture. After a few trials the motor was allowed to come up to speed, but as soon as the click of the starting winding cut-out was heard, it exploded violently, and was broken into a number of pieces.

In this shop black asphaltum paint was used on all windings. At times this paint got thick and was thinned down with benzine. This motor was assembled right after it had been painted, and inasmuch as it was a totally-inclosed motor, heat generated by the winding evaporated the benzine. The starting torque trials made matters worse. Then the motor shaft was released to allow it to come up to speed and as soon as the centrifugal, starting-winding switch operated, a spark was formed on the breaking of the circuit. This spark exploded the gas, wrecking the motor. I have been in this game for twelve years and this is the queerest experience I ever had.

Denver, Colo. A. J. M.

In the September issue A. J. M. asks if anyone has had an experience such as he had when a totally-enclosed motor exploded after it had been painted with asphaltum paint which had been thinned with benzine.

This queer explosion recalls to my mind a little incident which happened a few years ago. In this case a new field coil had been wound, dipped in asphaltum paint which had been thinned with benzine, and then baked. After being taken from the oven the coil was hung up to air dry.

As soon as this had been done a workman put the test leads across the field leads, causing a spark. The field coil was immediately enveloped in flames and was spoiled. The only explanation we could give for this was that the field coil, being hot and dipped as it was in benzine-thinned paint, was giving off gases that were inflammable.

While my explanation of the cause of this incident in my own experience may not be correct, for the benefit of A. J. M., I will state what I have done since then to prevent similar trouble, and suggest that others who have to dip and bake coils do likewise.

I always bake, for a few hours, any work on which paint thinned with benzine has been used, and then after removing from the bake oven, give the job a chance to cool thoroughly by air drying before tests of any kind are made. In the case of a rush job, where the time cannot be spared for baking and air drying, I use an air-drying lacquer for impregnating. This allows tests to be made or the apparatus to be put into service as soon as the assembly has been completed.

This method has proved to be very reliable and I have never experienced any trouble with it. I sincerely hope that other readers will benefit from the accounts which A. J. M. and I have given of the two cases of hard luck which we have had.

E. H. SHRIVER.

Master Mechanic,
Irving Smelting & Refining Works,
Irvington, N. J.

* * * *

I have read with interest the account by A. J. M. in the September issue, of the explosion of a ½-hp. motor while under test after being rewound. The particular grade of varnish used on the coils of this motor does not absorb all of the solvent unless it is well stirred. If the varnish filled all of the air holes, I can understand why the motor was blown up. The heating of the coils would drive the solvent out in the form of vapor. When this was mixed with air it would form a very inflammable mixture which would be likely to explode when the starting switch opened. A. C. ROE.

Detroit, Mich.

* * * *

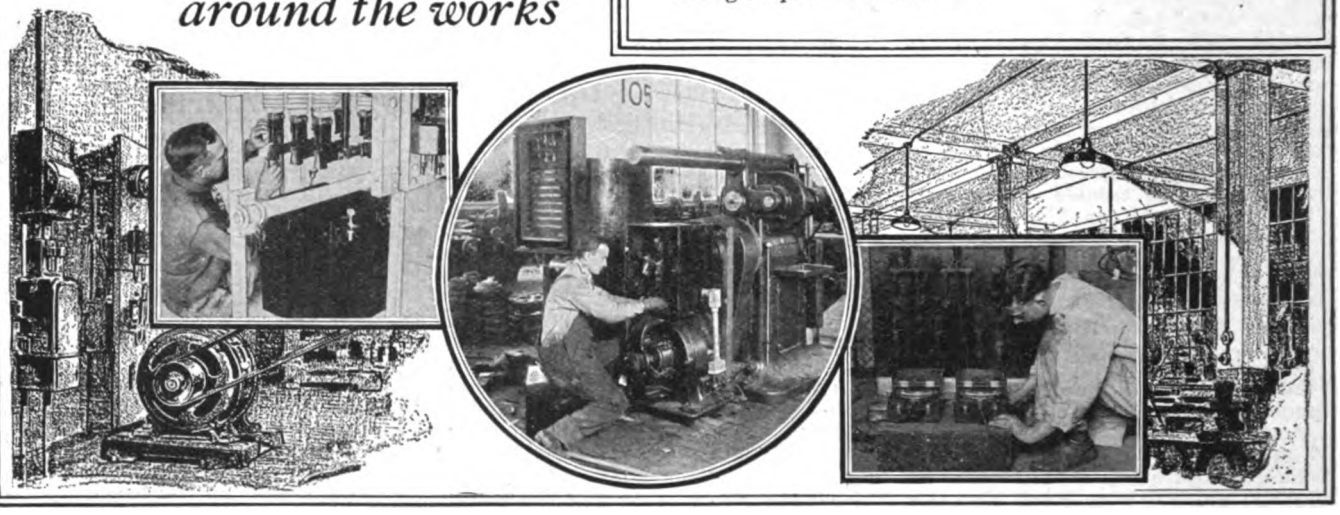
I think the answer to A. J. M.'s question in the September issue is that the motor should have been thoroughly dried out before it was run or tested, as benzine vapor and a spark is a dangerous combination in any total enclosure. This incident reminds me of a motor that I once saw set afire by a spark from its brushes igniting all of the field and armature windings after these had been washed with gasoline-soaked waste. H. S. RICH,

New Britain, Conn.

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SERVICE
around the works

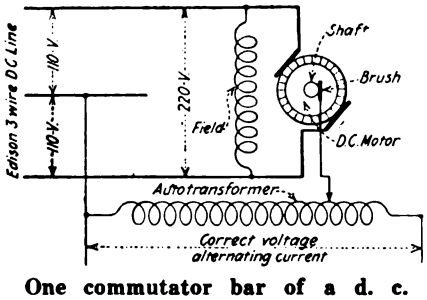
For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Easy Method of Obtaining Alternating Current From D. C. Machine

IN THE August issue of INDUSTRIAL ENGINEER, Philip G. Bernholz describes a method which he uses to obtain alternating current from a d. c. machine. I believe that, with conditions favorable, the following way of doing this is far better and much easier to put in operation.

Most d. c. motors are operated on twice the voltage of the lighting circuit on what is commonly called the Edison three-wire system. This offers an exceptional opportunity of getting alternating current for testing, by the following method: Obtain a good ground on the armature of a motor, which can be easily done by grounding one bar of the commutator to the shaft. When this is done, alternating current may be obtained from the shaft and the neutral of the three-wire system. I used an auto-transformer to get the correct voltage, as shown in the illustration. It would be best to have a brush on the shaft but I ran without one by simply grounding to any part of the motor frame. R. M. BEECHER.
Buffalo, N. Y.



One commutator bar of a d. c. motor is grounded to the armature shaft and alternating current taken from the shaft and the neutral of the three-wire system.

Wet Straw Aids Removal of Concrete Foundation When Blasting

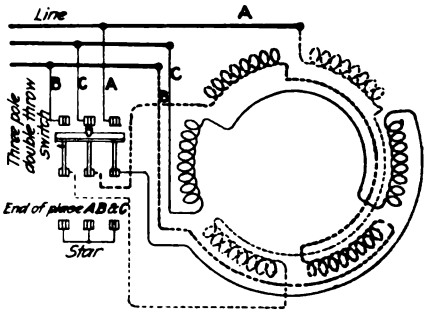
THE PROBLEM of removing concrete foundations without disturbing or damaging adjacent operating machines presents a complicated task to the industrial engineer. Drilling and wedging out the concrete, or breaking it with a skull cracker are both slow, tedious processes and in addition create a fine dust which may settle in and damage bearings of adjacent machines. The use of a skull cracker is usually prevented by the inconvenience of installation for such a small operation.

In one plant, blasting out a large concrete foundation in an engine room was tried. Thirty cubic yards of old concrete foundation in a power house were being removed to provide room for a new turbo-generator. In this case it was decided to blast out with dynamite. When the work was first started wood beams and tarpaulins were used, but were not satisfactory as they tended to fly about with each explosion and threatened to interfere with the turbines in operation close by. Finally, gunny sacks filled with straw and wet thoroughly were piled over the foundation while blasting. This deadened the shock and also prevented all but comparatively small pieces of concrete from flying around. In addition, an 8-ft. fence was built around the excavation to catch any small pieces which flew out at the sides from under the sacks. The wet sacks also kept down the fine dust which is so destructive to bearings. H. C. A.
Chicago, Ill.

Use of Star-Delta Connection to Start Motor Under Heavy Load

WE RECENTLY had a 3-hp., delta-connected, three-phase motor which overheated on starting. This was a 3,600 r.p.m. motor and was used for driving a tar purifier having a cylinder which runs about 18,000 r.p.m. when up to full speed.

The motor was started by throwing it directly across the line. Before it reached full speed it would be so hot that it would smoke freely.



When the switch is in the lower position the motor is connected in star. The windings receive 58 per cent of the voltage they receive when the switch is thrown upward, which gives a delta connection and is the running position.

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As a motor draws from two to three times normal current when starting and several seconds were required to bring the cylinder from rest to full speed the stator coils became very hot. After the purifying machine had reached full speed the motor would take care of the load, and its temperature would not exceed its rating. On examination of the motor it was discovered to be series-delta connected, so that the star-delta method of starting could be used. Therefore, in order to make the starting conditions less severe we arranged the motor to start connected in star and, after starting, to operate with the delta connection. The accompanying drawing shows how his was done.

As shown in the drawing the leads were brought outside the motor. A three-pole, double-throw switch was mounted near the motor with a lead from each line brought to the top terminals of the switch. Each phase lead from the motor was connected to the switch, as shown. The three bottom terminals of the switch were short circuited. When the switch is in the upper position the motor is series-delta connected and when in the lower position it is series-star connected.

The motor is started with the switch in the lower position, which gives the star connection and allows it to come up to speed slowly and without excessive heating. When the machine reaches full speed the switch is thrown in the upper position which gives the delta connection.

EARL BABER.
Illinois Power & Light Corp.,
Galesburg, Ill.

Power Saved by Use of Water Rheostat in Rotor of Pump Motor

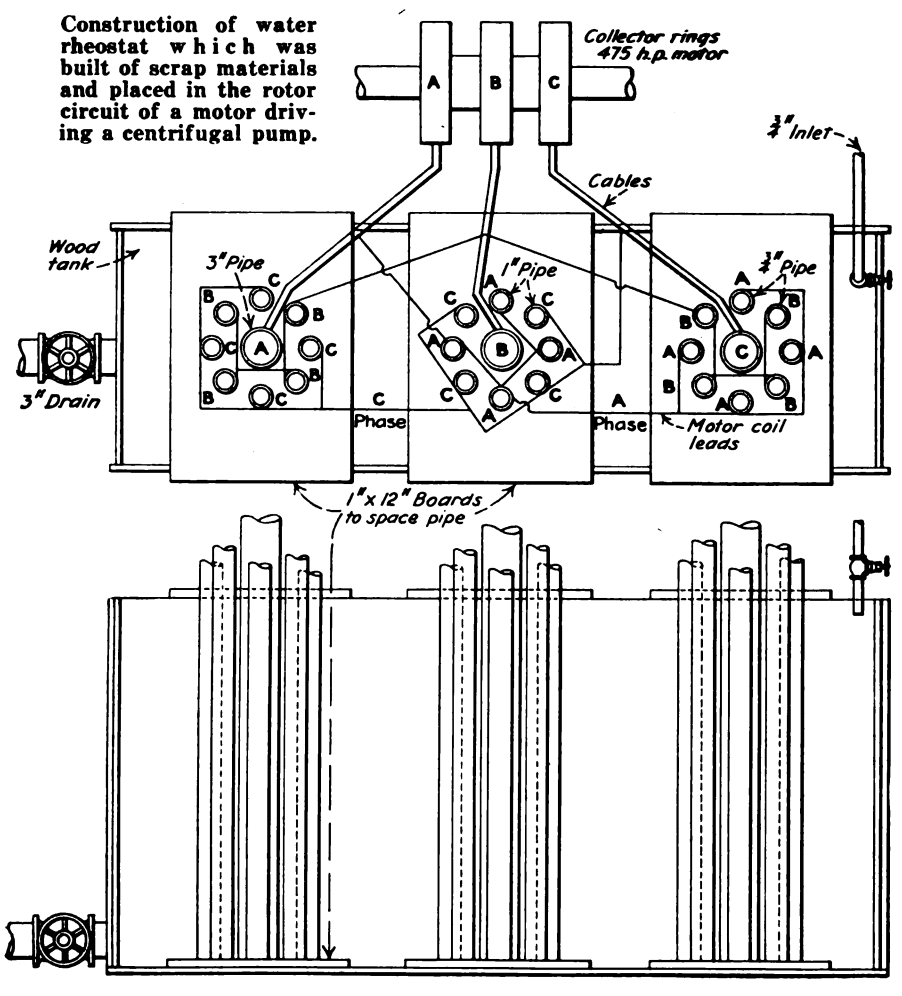
WE HAVE a 475-hp., 1170-r.p.m. 2,300-volt, three-phase slip-ring induction motor coupled directly to a 16-in. centrifugal pump operating under a 160-ft. head. As this was a booster station and the static head was 280 ft. the total head would be 440 ft. with the booster pump in operation.

After a series of experiments it was found that the pipe line would only withstand a maximum pressure equivalent to a 410-ft. head and this pressure was maintained by means of a by-pass valve cut in between the suction and discharge headers. By slightly opening this valve, water would pass back from the discharge side to the intake side.

As we were pumping into storage reservoirs which were constantly filling up or running down, the pressure was hard to maintain and the operator had his hands full. This method of regulation, while it worked, was very inefficient as the electrical horsepower input was 530 hp. while the pump was delivering only from 250 to 475 water-horsepower.

It was not deemed advisable to change the pump design, as later on the full head would be needed. After considerable thinking I decided to reduce the speed of the motor by means of a water rheostat cut in on the secondary or rotor circuit. I did not wish to purchase any new materials or equipment, as the idea was to save money; so I went to the junk pile and found an old mixing tank about 5 ft. long, 4 ft. deep and 2 ft. wide. There was also an assortment of iron pipe ranging from ½-in. to 3-in., in random lengths. I was forced to purchase 36 ft. of cable for the connection between the slip rings and the rheostat. For the connection between the pipe electrodes I stripped the insulation from a number of damaged motor coils; this gave me a supply of ⅛-in by ¾-in. copper strips.

I did not have much data as regards current and voltage on the secondary circuit at reduced speed, as an ordinary ammeter and voltmeter would not operate owing to the low frequency. However, I started the motor and with the starting resistance cut in about 50 per cent, I got a speed of 1,000 r.p.m. At this speed a 110-volt lamp across the slip-ring terminals burned at nearly full brilliancy, at maximum voltage. From these results, I assumed that the voltage would be about 100, on the average. From data which I already had, I knew that I would get a voltage drop of about 2,000 volts per sq. in. of gap at a current density of 1 amp. per sq. inch, using pure water as a solution. Owing to the high voltage at starting, 629 volts, I did not wish to have less than a 1-in. gap; so I had to figure on a smaller current density at normal speed. I thought that a current density of about 1 amp. per 9 sq. in. would be about right and estimated the average current to be 200 amp. Then, 200 amp. × 9 sq. in. = 1,800 sq. in. required per phase.



Construction of water rheostat which was built of scrap materials and placed in the rotor circuit of a motor driving a centrifugal pump.

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This was obtained as follows: Three 3-in. pipes immersed 48 in. in the solution equals 1,584 sq. in. Sixteen ¾-in. pipes gave an area of 2,304 sq. in. Eight 1-in. pipes gave 1,600 sq. in. area, or a total of 5,480 sq. in., which equals 1,829 sq. in. per phase. This was equalized by mounting the 3-in. pipes upright in the tank and surrounding them with eight smaller pipes spaced to allow 1-in. gap. This number of pipes and the spacing also gave the required gap between the 3-in. pipe and the smaller sizes.

The accompanying diagram shows the connections and when the rheostat was put into operation the phases balanced exactly. With a full load it was found that about 1,010 r.p.m. was required. My calculations and estimates were so close that this speed could not be reached except by adding a small amount of salt to the water in the tank. I was, however, surprised to find that the power factor which was normally 90 per cent now stood between 91 and 92 per cent. After the unit had been in operation four hours the water reached the boiling point and the motor had a tendency to speed up. This was overcome by draining out the hot water and adding cold.

The unit, as a whole, was very nearly self-regulating owing to the fact that the pump impeller was designed for a dropping power curve under maximum flow. This characteristic tended to stabilize the operation of the unit, as when the pressure showed any tendency to rise the extra power required automatically slowed down the motor. As a result when the desired pressure was reached the unit became very nearly automatic as regards holding this pressure.

A 24-hr.-per-day test, which lasted a week, was made and the results may be summarized as follows:

	Normal Operation	With Rheostat On
Speed, r.p.m.	1,170	1,000 to 1,150
Kilowatts	400	250 to 350
Power factor	90	91 to 92
Gallons per day, same both runs.		
Kilowatt-hours	9,000	7,500
Net saving per 24 hours		1,500 kw.-hrs.

This saving just about pays the operator's salary. The saving on the first day's run paid for the cable, and as the operators themselves installed the equipment and scrap material was used throughout, the remainder is clear profit. The outfit as shown was not built to be operated in regular service, but only to show that practical experience is as necessary as technical knowledge when economy is in the offing.

Indian Creek, Pa. P. N. E.

Ways of Eliminating Vibration In Electric Motors

VIBRATION is a common cause of failure of electrical machinery, particularly motors. Its elimination is, therefore, of prime importance if such apparatus is to be kept in first class running condition.

Motor Speeds for Ordinary Spur Gear Drives

Hp. Rating	Maximum	Best
1	1200	900
2	1200	900
5	900	900
7½	900	720
10	900	720
15	720	600
20	720	600
30	720	600
50	600	600
75	600	514
100	600	514
150	514	450
200	450	450

Vibration should have prompt attention when once discovered.

Vibration may be due to one or more of the following causes: (1) Unsteady foundation; (2) gearing at too high a speed; (3) unbalanced armature or rotor; (4) sprung or bent shaft; (5) large bore or loose bearings; (6) poor alignment and leveling; (7) defective coupling.

Trouble due to an unsteady foundation can usually be detected by inspecting the base carefully. Most of the other causes are not so simply detected, and it is not an easy matter to state just what is causing a machine to vibrate without checking up the possible causes and locating the trouble by elimination.

The most destructive kind of vibration is not a shake that can be seen, but a fine sharp buzz that can best be detected with the finger tips. Such a vibration is produced by gearing at too high a speed for a given size motor or poorly meshed gearing at appropriate speeds. Mechanical unbalance in armature, rotor or pulley will also cause this type of vibration. What is commonly called crystallization often results and leads to connections breaking loose, rotor bars breaking in two, and even the breaking of frames and bearing supports.

To prevent vibration by gearing, the motor speeds for a given horsepower, as shown in the table, should not be exceeded. This refers to plain spur gearing. Considerably higher speeds are permissible if a flexible coupling is interposed between the motor and the first pinion, or if herring bone gearing or silent chain drive is used. With belting also, from 1½ to 2 times the speed allowable for gearing is permissible. Therefore, if a motor with a speed higher than that given in the table is encountered and is giving trouble from vibration, the remedy is to change the type of drive to any of those mentioned above.

If the armature or rotor of a machine is not properly balanced, considerable vibration will result. The spiders of large machines are usually cast with grooves in which to place the lead for balancing. On smaller machines it will be found necessary to resort to some other means of storing the lead. One method is to drill and tap the spider so that the lead may be fastened with a machine screw.

If no balancing rails are available, a "running balance" may be obtained as follows: Select a small piece of lead and wedge it into the grooves, or otherwise secure it in place. Try the machine at no load and at various stages up to full load. If the vibration is practically the same, try heavier pieces until some change is noted. By changing the amount and location of the weight the vibration can be practically eliminated, if the trouble is due to unbalance.

A sprung shaft will cause vibration, the amount depending on how much the shaft is bent. The vibration will usually be localized in one of the bearings and for this reason the cause may be difficult to distinguish from several others. To check an armature or rotor for a bent shaft the best method is to place it in a lathe. A rough check may, however, be made with the armature or rotor in place, by the following method: Arrange a movable support for a lead pencil and gradually move it toward the shaft at a point as far from the bearing as possible. As soon as the pencil has made light contact with the shaft, stop the machine and examine the shaft carefully. If the mark extends all the way around shaft the latter is, in all probability, straight. If the mark

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does not extend all the way around the shaft, several checks should be made at different points on the shaft. If these all give the same results the armature or rotor will have to be removed from the machine to be straightened.

The whipping about of a journal in its bearing, and sometimes of a bearing in its housing, is a fruitful source of vibration. If the bore of the bearing has become worn and is too large for the shaft, it will have to be rebabbitted or replaced.

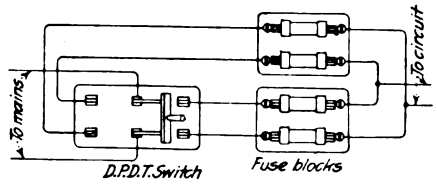
Where the two units of a coupled set are not in good alignment, there is bound to be some vibration. A shaft that is not level will also cause vibration. The remedy in both cases is obvious.

A longitudinal, or to and fro, motion of an armature or rotor is usually caused by a coupling which is incorrectly drilled for the coupling pins. The holes for these pins should be accurately spaced and at the same distance from the coupling center. In addition to this, the holes should be drilled at right angles to the coupling face. If a coupling is bored to fit a larger size shaft, considerable care must be exercised to get the bore exactly at a right angle to the coupling face; otherwise serious trouble from vibration will soon develop. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

How to Restore Service Quickly after Fuse Blows

AN ARRANGEMENT which makes it possible to restore the power in a circuit immediately when a fuse blows is shown in the accompanying diagram. This is a very simple yet useful application to any circuit where time of outage means money. The only alterations necessary to the ordinary circuit are to change the present switch in use



When a fuse blows the switch is thrown in the opposite direction to restore power to the circuit.

to a double-pole, double-throw switch and add an extra fuse and block.

Of course, if there is a short circuit or other trouble in the circuit the second fuse will blow out. The trouble must then be located and removed, but for ordinary blowouts, by throwing the switch in the opposite direction the plant will immediately have power again for working purposes and the blown fuse may be replaced for further emergency. DONALD L. HOARE.

New York, N. Y.

Motor Failures Caused by Loose Oil-Switch Blade

A NUMBER of 150-hp. motors in a New England cotton mill burned out with no apparent cause, shutting down important departments and causing much trouble and expense. An inspection disclosed the fact that one of the blades of an oil switch feeding the motor circuit had slipped down on the pull-rod. On closing the switch poor contact was first made but it carried sufficient current to start the motors satisfactorily. Subsequent vibration, however, caused the blade to open, thereby bringing about single-phase operation of the motors. As they were fairly well loaded they became overheated when running single-phase and finally burned out.

Boston, Mass. H. S. KNOWLTON.

Some Causes of Oil Leaks in Bearings and Their Prevention

ONE OF the first steps in stopping the leakage of oil at the bearings of machines, is to find the cause. A study of a number of cases shows that they usually are the result of some one of the following causes: (a) A porous bearing; (b) oil gage joints not properly sealed; (c) bearing end-plates not properly sealed; (d) oil too high in the bearings; (e) shafts not level; (f) eccentric oil rings. It is generally easy to check over these causes and see which is at fault in any particular instance.

Trouble due to porous castings and improperly sealed joints at the oil gage or bearing end-plates may be corrected by the application of a mixture of red lead and glycerine made up into a thin paste. Before applying this paste it is best to thoroughly clean the parts affected with carbon tetrachloride, to remove all traces of oil. After applying this thin paste of red lead and glycerine the connections should be made as tight as possible and then allowed to set for two or three hours before oil is again put into the bearings.

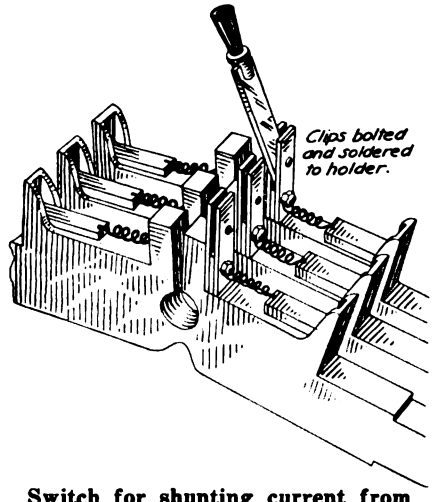
If there is still a leak at the gage after an attempt to correct it by tightening the sight, it shows that the cork washer is probably defective or the gage glass cracked. Creeping of oil along the shaft may be due to too much oil in the bearings or to a shaft that is not level. Occasionally it is also caused by loose or broken babbitt in the bearing houses. It is well to correct either of these difficulties immediately as each may cause more serious trouble. An eccentric oil ring will sometimes spatter oil on the underside of the bearing cover and allow oil to seep through to the outside of the bearing. The remedy for this is to put in a new oil ring, or straighten the old one. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

Short-Circuiting Switch to Relieve Controller while Motor is Running

A SHORT-CIRCUITING switch which we have used on the secondary of type C Crocker-Wheeler motors and found to be very satisfactory is shown in the accompanying drawing. When the motor is running this switch is closed. It shunts all current from the controller and also permits repairs on controller while the motor is running.

This device consists of a knife switch and two clips which are mounted on the brush-holder arm. The clips are fastened under the bolts which are used to tighten the



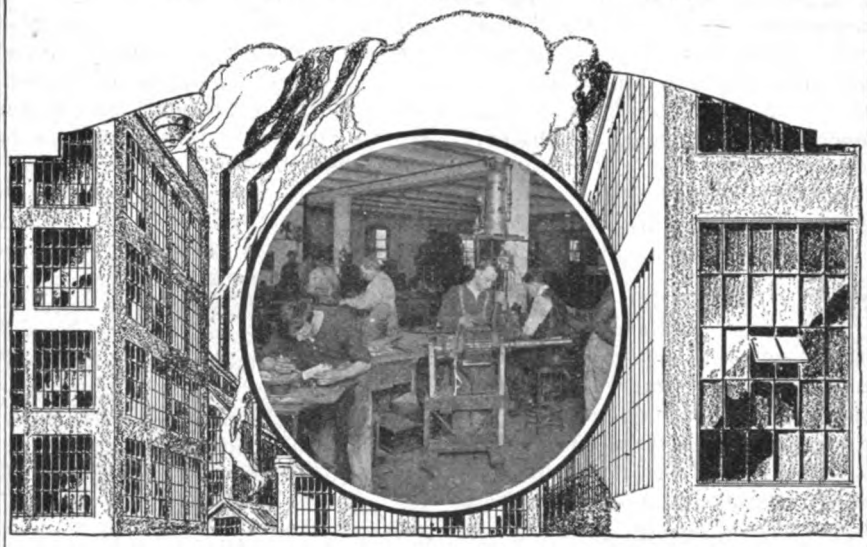
Switch for shunting current from starting controller.

brush holder on the supporting arm and, in addition, are soldered to the brush holder. J. H. SAUVE.

Temiskaming, Que., Can.

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In the Repair Shop

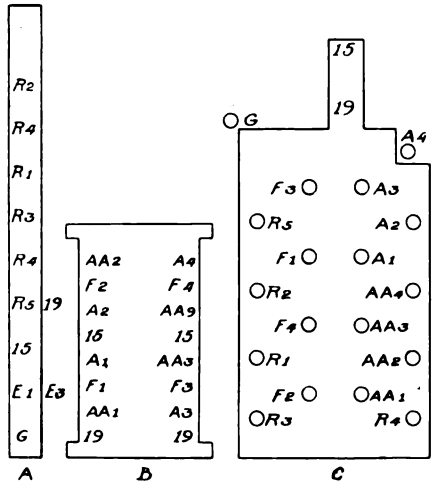


This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Marked Templets for Ringing Out Car Controllers After Overhauling

AFTER an electric car controller has been overhauled it is customary to ring out the connections between the power fingers, reverse fingers, cut-out switches and conconnected are plainly marked, or if any of the internal wiring has been disturbed in course of overhauling. If all points to which the wires are connected are plainly marked, or if the overhauler is thoroughly familiar with the connecting scheme of the controller in question, there is little likelihood of a mistake being made when due care is observed in the ringing out. Where the markings have, however, become unreadable through repeated shellacking or where a number of the repairmen are new to the business, marked templets have been found very useful to the controller overhaulers in the electric repair shop of the Brooklyn Rapid Transit Company. These templets are made of 1/16-in. sheet fiber. The templets shown in the accompanying illustration are used for ringing out the connections of a K-28B controller. Before installing the cylinders, templet *A* is laid alongside of the power finger-board; *B* is dropped into the space between the reverse finger boards, and *C*, the holes and notches in which register exactly with the connecting board posts, is so placed over the connecting board that the posts come up through the holes. As the templets are plainly marked it is an easy matter to ring between all connections of the same markings and thereby determine that every post or finger is connected to every other post or finger to which it should be connected. Once it is correctly laid out and marked, a templet serves virtually as a most simple form of controller wiring diagram.

J. A. HORTON.
Brooklyn, N. Y.



These templets are placed in or on the controller when ringing out the connections.

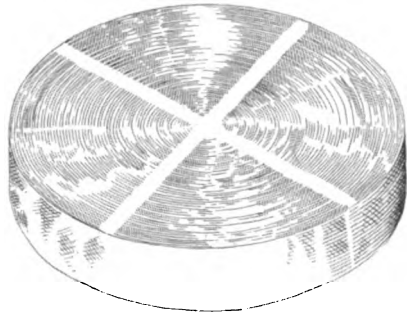
Two Methods of Making Rolls of Cotton Tape More Easily Handled

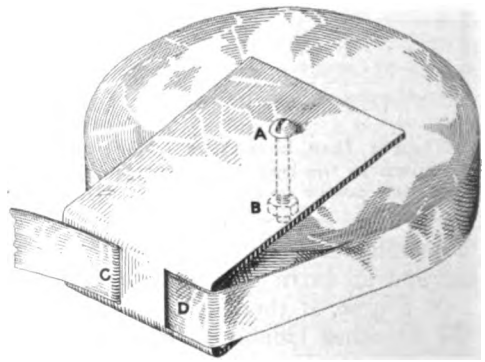
PROBABLY every electrician has experienced the exasperating circumstances of having a roll of cotton or linen tape slip out of his hand and unroll across the floor, necessitating him getting down from an awkward position, as on a transformer, to re-roll it. Such mishaps as this might make even Practical Pete lose his smile. To prevent this, repairmen will find either of the following methods which I have used satisfactory.

The first method is to stripe two thin cross-lines of glue across one side of the roll, as shown in the accompanying sketch at the left, and similar crossed lines on the other side of the roll with the cross rotated 45 deg. Only a small amount of glue is required for this and it may be applied with a small brush or even with a stick or the finger. This keeps the tape from unrolling too easily, although it does not interfere with its use.

Another method is to use a tape holder, as shown at the right in the accompanying sketch. This holder can easily be made as indicated out of 1/16-in. brass or copper. A different holder must be made for each size of tape used. The tension on the tape may be varied by tightening or loosening the screw *A* in the brass nut *B*, which is soldered to the opposite side of the holder. The two slits *C* and *D* are made the width of the holder and about ¾ in. apart.

If you have ever had a roll of linen or cotton tape get away from you, why not try one of these methods of preventing it?





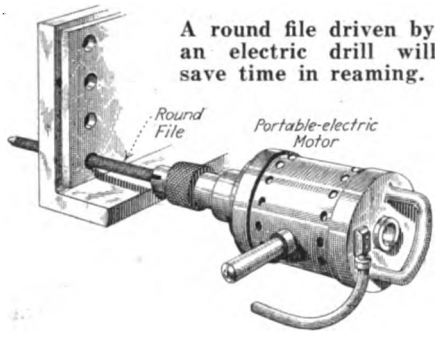
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The tape should be torn at the edge of the holder and not at *C*.

San Francisco, Calif. S. H. SAMUELS.

Motor-Driven File Lessens Work Of Reaming Small Holes

A HAND REAMER to take off burrs and sharp edges and to make the required clearances for entering shafts, bolts and rivets can be made with a file and a portable motor or an electric drill. Ordinarily these various clearances are



A round file driven by an electric drill will save time in reaming.

made with chisels, punches, hand reamers and files, but a round file driven at a good speed by a portable motor will accomplish a variety of work with a considerable saving of time over the other methods.

Sheet-metal parts, from the springy nature of the material, often overlap the holes for retaining screws or interfere with the assembly of other pieces. Such parts often require file work or chiseling. The improvised hand reamer, with its rapidly revolving file, will save much time on such work.

Washington, D. C. G. A. LUERS.

Armature Banding Machine Made from Old Lathe

IN A REPAIR SHOP where many direct-current armatures are repaired, some trouble was experienced in the banding operations, and several armatures failed because the banding was improperly done. Apparently this was due to insufficient tension in the banding wire, and to avoid possible additional failures an old engine lathe was converted into a banding machine, as shown in the accompanying illustration.

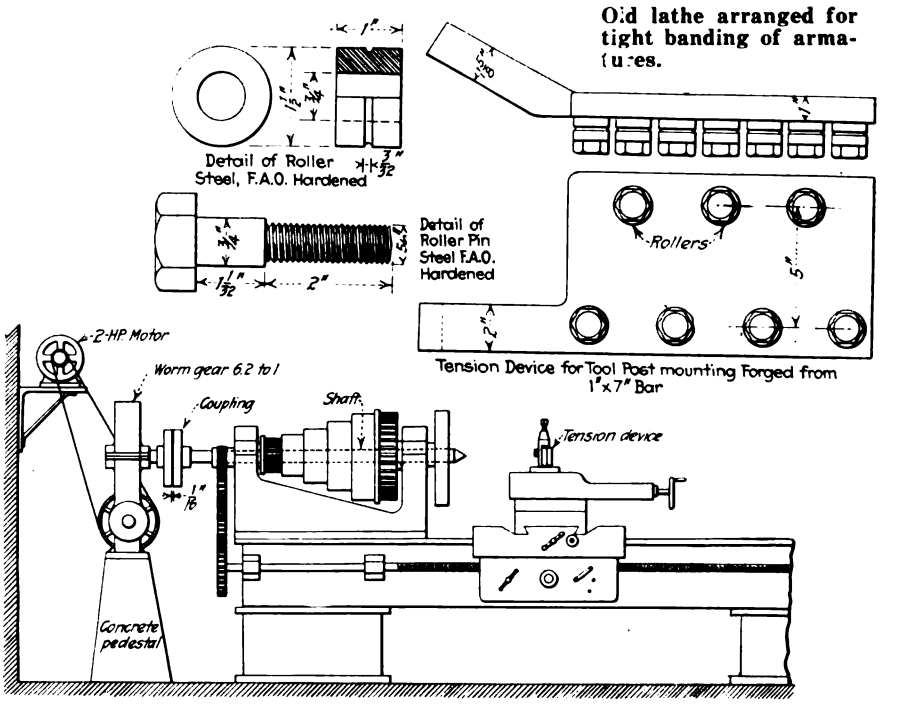
The lathe was so badly worn that accurate machine work could not be done with it and orders had been given to scrap it. It was noticed that the spindle was hollow; so a piece of shaft was turned down, the finished diameter being very slightly smaller than the hole in the spindle. The face-plate end was turned with a taper to fit the taper bore of the spindle after which the center was rough turned and hardened. The shaft was placed inside the spindle and after being lightly tapped into place a shaft collar was put on at the outer end to hold it in place. The center was then finished by grinding with a tool-post grinder. The worm-gear drive unit, having a ratio of about 6 to 1, was placed in position on a concrete pedestal as shown. The flange coupling was placed on the shaft ends and lined up, leaving 1/16 in. between the coupling faces. Normally the couplings are bolted together by 2-in. x 5/8-in. turned bolts, a 1/16-in. fiber sheet fitting between the coupling faces. The worm gear is driven by a 2-hp., 950 r. p. m. direct-current motor, the speed being controlled by a hand-operated rheostat.

Armatures to be banded are handled in the usual way except that the lathe dog used fits in the face-plate slots tightly. The worm gear, being self-locking, always holds the band wire under tension while it is being soldered.

The old-fashioned fiber-block clamp which was used as a tension device was replaced by the tension device of which the details are shown. The 1 5/8-in. x 2-in. shank fits into the tool post of this lathe, the band wire being zig-zagged back and forth over the rollers as many times as may be necessary to produce the desired tension. By means of the change gears, set to cut from ten to sixteen threads per inch, the banding wire is fed on to the armature with perfect regularity and at a uniform tension.

When necessary to use the lathe to turn or slot commutators, the bolts and fiber spacer are removed from the flange couplings, allowing the lathe to be driven through the cone pulley, as is usual. The general principle of the tension device was brought to the shop by a machinist who had made a similar device to hold a uniform tension on spring wire while winding springs of 1/8-in. diameter wire in a lathe. The whole arrangement is most satisfactory in every particular.

Bonne Terre, Mo. H. R. WASS.



Old lathe arranged for tight banding of armatures.

The Invention and Development of Enameled Wire

THE FIRST commercial baked enameled wire of record was apparently invented by John H. Vinton for use in connection with shoe machinery, and not for electrical purposes. Mr. Vinton's U. S. Pats. Nos. 662,247 and 662,248, Nov. 20, 1900, disclose a product and a process, respectively, which was subsequently applied to electric conductors. In these patents it is claimed that the product may be bent into small articles without stripping, cracking, or breaking off the coating, and that the wire may be safely used with automatic machinery.

This process consists in passing the bare wire through a liquid or varnish having the consistency of

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water, and then baking in an oven at a temperature of about 550° F. If the temperature is too great "the life is taken out of the coating and the latter is reduced to a powdered form, which is readily brushed or stripped off the wire." The liquid is composed of copal gum, linseed oil and turpentine. Bone-black may be added. From the bath the wire passes over a wick before entering the oven.

It may be generally stated that for making enameled wire, oxidizing varnishes of the character just described consist of a base and a solvent. The base consists of some form of vegetable oil, as linseed oil, castor oil, and so forth, and a hard resin, as copal gum (or sometimes an asphaltic compound) to give the film a dense body. Solvents consist of turpentine, kerosene and other similar materials. Unlike a wood-protecting varnish, the oxidation of the oils and gums is retarded as much as possible until the varnish-coated wire enters the enameling oven, when the oxidation takes place very rapidly. The film is a partially carbonized residuum of the materials contained in the varnish. The materials used in the base do not dry out at ordinary temperatures. Hence, the temperature must be kept constant at a value found by experiment. Drafts of air in the ovens tend to make the product uneven.

In U. S. Patents Nos. 806,574-7, Dec. 5, 1905, just expired, George H. Rupley describes an insulated wire and three processes, wherein the residuum constituting the enamel film is obtained from vegetable oils by distillation. The presence of oxygen is not required. While linseed oil gave the best results, cottonseed oil and even corn oil were successfully employed. The color of the coating produced on the wire varies from brown to black, according to the thickness. Raw linseed oil is mixed with 2 per cent each of oxid of zinc and litharge and the mixture thoroughly boiled until a partial saponification of the oil is effected. The glycerids are broken up and glycerin and other elements of the oil which prevent the film hardening are driven off. Rosin oil or turpentine is added after the oxids are completely combined with the oil.

After the wire passes through the solution it enters an oven having a temperature of about 500° F., where the solvent is volatized and a fractional distillation of the hydrocarbons produced from the oil by the preliminary treatment is effected. The film thus produced is a hardened coating of residues of fatty acids, or a residuum of destructively-distilled vegetable oil.

Of the two general processes described above, the latter is more rapid and is cheaper.

Charles P. Steinmetz appears to be the originator of the first structureless-cellulose coated wire. In U. S. Patent No. 669,358, March 5, 1901, he was granted the broad claim: "A bare wire covered with a film of structureless cellulose." Cotton wool was dissolved in an ammoniacal solution of cupric oxid. After passing the wire through the solution and allowing it to dry it was passed through diluted hydrochloric acid, washed with pure water, and dried. Further improvements along this general line were developed principally by Elihu Thomson and John J. Callan.

Early attempts, of historical interest only, are mentioned below. In U. S. Patent No. 58,217, Sept. 25, 1866, James J. Clark and Henry Splitdorf claimed the following: "Making helices for electro-magnetic and magneto-electric machines from wire insulated by passing it through any powdered material, such as powdered glass, stone, sand, or paper-pulp, after the wire has been passed through any sticky fluid, and before the sticky fluid becomes dry." H. Redding, U. S. Patent No. 189,262, April 3, 1877, describes a process of coating wire with shellac and then passing it through candle flames to give it flexibility.

Several of the larger electrical manufacturers developed the wire-enameling art without taking out patents. Therefore, little is known as to whom credit is due besides those mentioned. Furthermore, it is not known that any suits were ever brought against any alleged infringers of the above-mentioned patents. After the varnish is baked on the wire there is no way of telling what was in the varnish.

Enameling wire is becoming an old art. Wire-enamel varnishes, as well as machines for producing enameled wire, may now be obtained. Nevertheless, there is much room for improvement. For instance, the film is not waterproof, as it contains "pinholes." The number of pinholes in a given length is used as one standard of judging the quality of the film. One way to detect pinholes is to run the enameled wire slowly through a mercury bath with voltage impressed between the conducting core and the mercury, and with a voltmeter or other indicator in series. A voltmeter having a resistance of 100 ohms per volt will not only show the number of pinholes in a given length, but will indicate the insulation resistance according to well-known principles. While some enameled-wire manufacturers do not advocate the mercury-bath test, it has been used for testing.

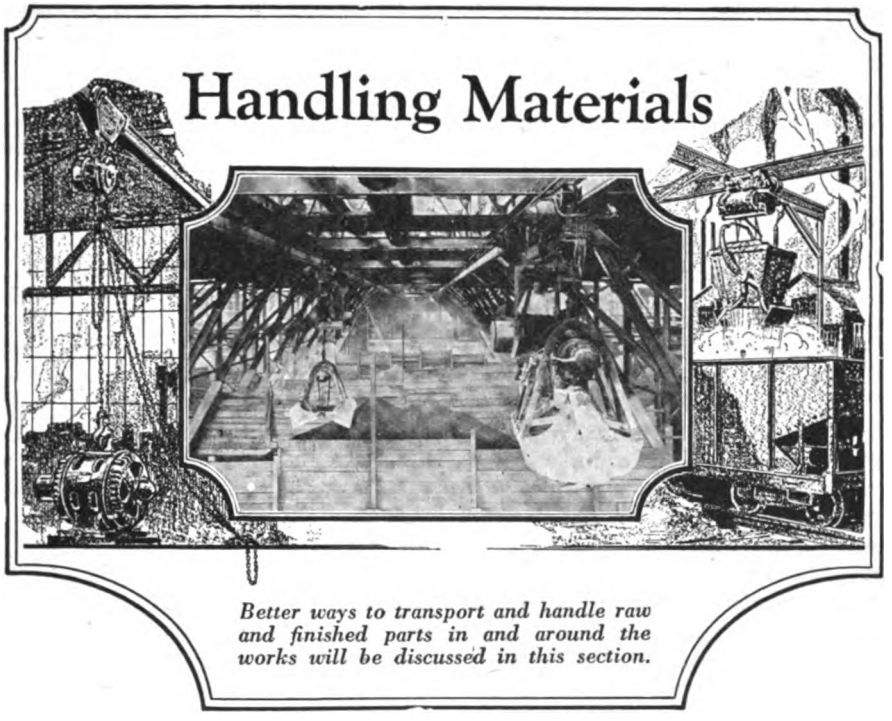
While it is obvious that cotton-covered wire, for instance, is not waterproof, the thickness of the insulation due to cotton is much greater than that due to enamel, and metal slivers and copper dust cannot protrude through the insulation.

Because of the vast market for enameled wire, new developments will be noted with interest. The present tendency appears to be along the lines of production by passing the wire through the ovens at high speeds and increasing the oven temperatures. With the production of a waterproof enameled wire, coil impregnation should be quite unnecessary, excepting to fill up the interstices between turns and thus facilitate the cooling of the coil. However, the invention of enameled wire has increased the efficiency, decreased the size, and generally lowered the cost of electromagnetic devices in which it now replaces cotton- and silk-covered wire. Several enameled-wire manufacturers claim a dielectric strength of 600 volts per mil for their product.

Combinations of enamel and single-cotton, and enamel and single-silk have displaced the more bulky double textile coverings in many cases, and have still left the required electrical and mechanical properties. In this connection, it is interesting to note that Henry Splitdorf, a noted manufacturer of magnet wire in his time, patented under date of Dec. 14, 1875, U. S. Patent No. 171,185, a "mode of constructing insulated wire by first coating the wire directly with shellac or other non-conducting gummy material, then winding silk or other thread on the wire, and finally heating the whole to unite the gummy coating and thread."

CHARLES R. UNDERHILL.
Consulting Engineer,
White Plains, N. Y.

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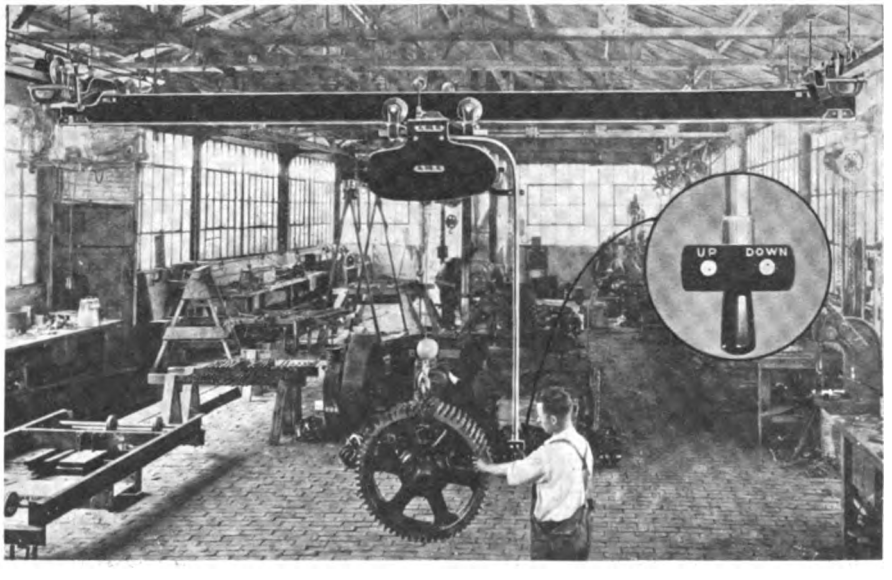


Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

How One-Hand Individual Hoists Reduce Production Costs by Saving Helpers' Wages and Speeding the Work

SOME types of industrial work may easily be performed by one man except for short intermittent periods when he requires the aid of a helper, such as for lifting work on and off machines, holding work during fitting and assembly, turning work over, and similar tasks. Even with the best of planning this helper is idle frequently and if he serves several men will occasionally necessitate one or more of them waiting on him. The same condition exists in many plants where a number of men or groups of men rely on a few large cranes or hoists to serve all of them. These types of work offer many opportunities for small hoists and other material-handling equipment.

One company, for example, installed over 50 light-weight hoists on trolleys, as shown in the accompanying illustration, as auxiliary equipment to supplement the work of two heavy cranes, so that each group of men could have a hoist as they needed it and not have to wait. The hoist pictured here (The Cleveland Crane & Engineering Company, Wickliffe, Ohio) is a one-hand push-button control hoist where all the motions of handling the hoist are performed by one hand, thus leaving the other free to perform other work. A close study of many kinds of intermittent labor will often indicate a means whereby one man and some mechanical device can do the work, instead of gangs of helpers. Mechanical devices can usually do this work so much more economically that even though they may be idle at short times, the idleness is not as expensive as that of large gangs of men. Besides saving the services and wages of helpers, which are easily measured, individual hoist installations usually give additional, and less easily measured, economies through increasing production by eliminating waiting time and visiting time as well as increasing the speed when making the lift.



A type of one-man push button control hoist on a monorail trolley which is often used to replace helpers in miscellaneous shop work.

One Hours' Work of an Electric Lift Truck in an Industrial Plant

ONE OF the most difficult points when considering the installation of modern material-handling equipment is to visualize what it will actually do. One method of doing this is to see the work actually done in a typical installation. If, for example, the solution of a trucking problem is considered, some idea of what a truck will do would be obtained by following the work performed by a truck in another plant.

Trucking may be roughly divided into two classes: (1) Hauling in which the same kind of material is carried over a specific route, as coal from yard to bunkers and (2) general miscellaneous factory hauling—the movement of anything to and from anywhere within the buildings or yard. It is this second class of work which is the most difficult to visualize.

For much of this general hauling it is best to use platforms or skids, particularly if the work is to be moved from machine to machine or department to department. With the skids, the work may be left on the platform and replaced after it is finished and so eliminate the obvious rehandling. The entire platform can be lifted up by an electric or hand-lift truck and moved as quickly whether it contains one unit or several thousands on the platform or box skid.

As it would occupy too much space to list all of the trucking movements in a day's work, this item will cover only one hour's activities in the Cleveland, Ohio, plant of The Lin-

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coln Electric Company. These operations, however, are not special but typical of a regular daily performance. In this an electric elevating platform lift truck (The Elwell-Parker Electric Company, Cleveland, Ohio) is used with platform or skid to conserve the time of the truck when loading and unloading. One hour's work was as follows:

Starting at 9 o'clock in the morning, four loads of punched laminations, *A*, were carried on the truck from the punching department in the basement to the storeroom, a distance of approximately 200 ft. The truck then proceeded to stockroom No. 1 where three loads of rotors, *B*, were taken to the general assembly room in the main building. The next job on hand was to transfer three loads of wound frames, *C*, from the insulating dip oven to the assembly floor in the main building. The next task found to do was to carry a stacked rotor from the machine shop down an incline to the basement and then by elevator up to the third floor for winding, *D*. These eleven hauls completed the hour. These jobs were not a "set-up" but in each case after the trucker had completed one group of operations he had to find his next load, carry it to its destination and then seek the next, and so on. It is conservatively estimated by the superintendent in charge that it would have required at least ten men with hand-trucks to do the work now being done by this one electric truck. Even then it would be practically impossible for them to handle some of the larger castings and frames at all.

Although this hour's work is typical, some of the other tasks handled are of interest. For example, in the course of a day this truck is called upon to bring rough castings from the storage yard to the machine shop, to deliver wire and copper to assembling floor, to take completed motors to storeroom or shipping department as the occasion requires, and, in fact, handle any parts that are used in the manufacture of the motors as they are taken through the various departments and operations. The weight and the size of the loads in this miscellaneous work vary considerably but the average load will weigh between 1,500 and 2,000 lb.

One especially interesting operation of this truck is work on a 15-deg. incline, as shown at *C* in the accompanying illustration. These inclines are located between the basement and the first and second floors. To enable the truck to operate in wet weather it was necessary to cover the incline with a wire mesh. The truck is also fitted with side rails which extend around the operator, as is shown in the accompanying illustrations, and not only protect him from injury in case he should accidentally back into a wall, but also automatically open swinging doors of the different departments as the truck approaches. The truck is equipped with twelve-cell, fifteen-plate Ironclad Exide batteries. One charge, which costs approximately 25 cents, keeps the truck operating all day except where the work is unusually heavy or during bad weather. Under these unusual conditions a boosting charge is given at noon.



Four transfer jobs handled by an electric industrial lift platform truck.

These four miscellaneous handling jobs indicate the wide variety of work which an electric industrial truck is capable of doing inside an industrial plant. Similar miscellaneous handlings of which these are typical might be found in almost any other plant. Practically the only restrictions on handling in this way are the width of aisle and strength of floors and elevators. Notice the guard rail around the truck operator.

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Ways of Mounting Small Motors

(*Continued from page 593*)

The same size of motor drives the screw machine (shown at the right) and this is mounted on 1¾-in. by ¼-in. strap iron carried by two 2-in. by ¼-in. straps at right-angles, the latter being attached to a bracket of 1½-in. by 1½-in. by 3/16-in. angles. Flexible armored conductor fits admirably into the wiring arrangements in cases like this where turns have to be made in going to the motor and to the control switch or box.

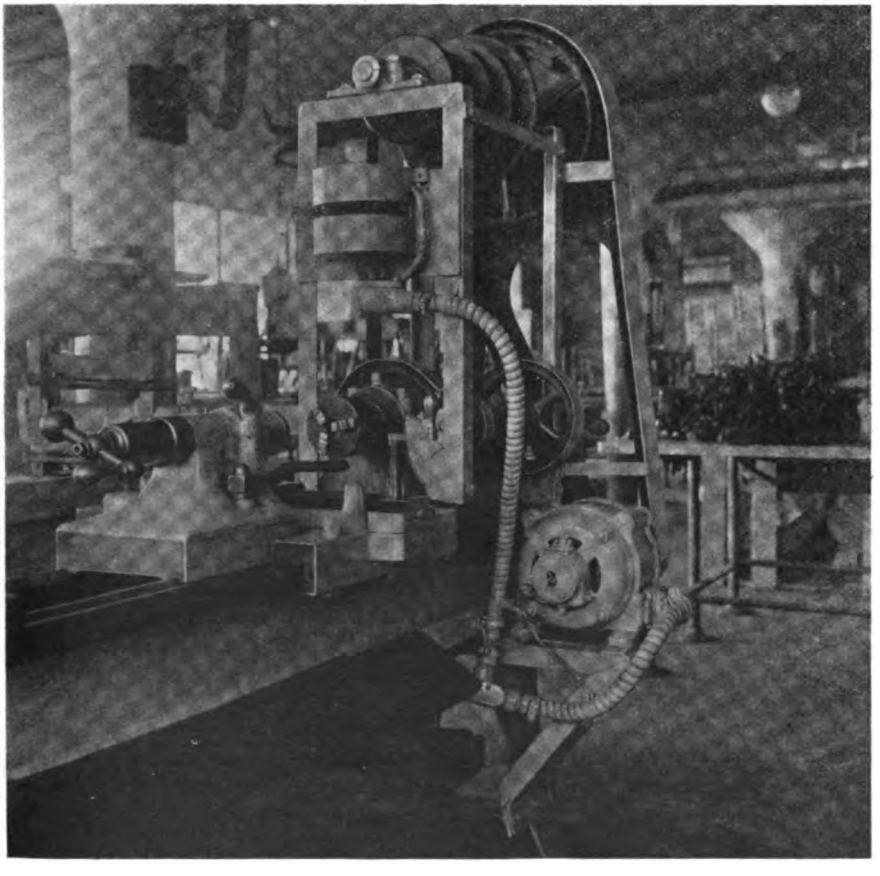
Another example of exterior driving from above is seen in *B* of Fig. 3, which also shows an inside-mounted motor in service. In the first case, the framing required to support the shaft bearings of a duplex drill (shown at the left) was also utilized as a base for mounting a 1-hp. motor at the top of the tool, the motor being mounted on ½-in. by 1½-in. U-shaped straps bolted into the tool frame. The operator does not have to step out of position to manipulate the starting switch. The lathe at the right is driven by a ¾-hp. motor mounted within the frame on a base formed by the cross-bracing between the upright end supports. Both of these motors are mounted so as to occupy no space otherwise useful in the shop.

Underslinging the motor for a small drill-press is shown in *B* of Fig. 4. A quarter-turn belt drive was required in this case. Strap-iron supports ⅜ in. thick and ⅞ in. wide proved sufficient to carry the ½-hp. motor used, and the wiring problem was simplified by the location of both motor and starting box close to the column outlet from which the unit is supplied with energy.

Fig. 2 shows three bench applications of motor drives. In these cases portability often is a factor of importance; or else maximum ease of starting and stopping is required. At *A* is a motor-driven screw-and-bolt driver. The reversing switch on top of the motor provides for the most rapid handling of this light work, and rigid conduit feed effectively protects the operator and the wiring. A portable polishing motor is shown in *B* with detachable clamp straps for bench service. Ruggedness is not sacrificed to portability. The simplicity with which a small motor of the coil-winding type can be mounted on a right-angled wooden base and attached to a bench is shown in *C*. These small motors fit into bench work in a way that is little appreciated in many shops, and should be more widely used.

From a closer study of these views it will be seen that there are excellent opportunities to economize on material as well as in space in utilizing small integral and fractional-horsepower motors for individual drives in repair shops. Short runs of wire, well protected by rigid or flexible conduit and control switches located as close to the motor as the needs of the tool operator allow, all spell minimum cost of installation. The amount of motor driving that can thus be put into either an old or a new shop without interfering with aisle space is surprising. The mechanical requirements of such short drives should, of course, receive due attention in planning motor locations.

Fig. 5—Engine lathe drive with belted motor showing protected motor switch mounted above the chuck.



Graphic Meter as a Watch Dog

(*Continued from page 584*)

changed somewhat and the process may be regulated by observing the variations from the normal load.

An approximate check of the load only may be obtained with an alternating-current ammeter due to the fact that the power factor of an induction motor decreases rapidly below three-fourths full load; thus the current at no load will often be equal to half the current at full load. However, the current peaks above the rating of the motor may be watched and where the strength of the mechanical drive is known, the point where the mechanism would be broken may be avoided. The current as shown by a direct-current ammeter is of course directly proportional to the power input to the motor. The direct-current chart on page 584 shows the wide variations of load even with good operation while the chart from the alternating-current ammeter shows only a minor current variation.

A sufficient number of indicating instruments should be used in addition to one recording meter in order that the operator may check the performance of the equipment from the various locations where the work may require his presence. The indicating meters also should be used to check the graphic meters.

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Armature and Field Defects

(*Continued from page 578*)

or sparking and a change of voltage in a generator is found with a variation in load, the trouble may be due to incorrect setting of the brushes or to poor adjustment of the interpole winding.

The position of the brushes should be tested first. Probably the best way to set brushes on a commutating-pole machine is to run it as a series motor, using the armature and commutating poles only, the main field coils being entirely disconnected. When the brushes are set so that the flux is divided equally on both sides, the motor will not rotate and there will be no torque tending to produce rotation. An armature resistance will have to be used to keep the current down to about twice full-load current. When the brushes are just about in the right place, the amount of torque may be so small that it will not actually produce rotation, but the torque can be felt by turning the pulley around by hand, noticing whether or not it turns harder in one direction than the other. The brushes must be so accurately set that there is no torque in either direction when twice full-load current is flowing through the armature and commutating poles.

After the brushes are correctly set if the trouble still exists the interpole is not properly adjusted and the manufacturer of the machine should be consulted.

(10.) Unequal Air Gaps and (11) Worn Bearings.—These troubles will be treated together because the effect of worn bearings is to produce unequal air gaps. Fig. 5 shows a four-pole machine in which the bearings have worn sufficiently to make the air gaps much smaller at the lower than the upper pole piece. This results in an increase in the magnetic flux in the bottom air gap and a decrease in upper air gap. This produces a higher voltage in the coils in the lower half of the armature.

In a wave-wound machine the effect is neutralized as the windings pass under both poles from coil to coil, but it may produce poor commutation at the brushes.

In a lap winding the trouble is more serious and may result in the lower half of the armature carrying all of the load or in extreme cases the difference may be sufficient to reverse the current in the upper half of the armature. Under these conditions the upper half of a generator will be operating as a motor receiving its current from the lower half, or in a motor the upper half may be operating as a generator driven by the lower half.

Unequal air gaps may be caused at other pole pieces by a variation in length of the pole pieces, poor centering of bearings or bearing pedestals or by belt pull. It is well to give air gaps careful and frequent attention.

12. Flux Distribution.—It is not within the province of this series of articles to discuss flux distribution in detail. Poor flux distribution will cause sparking, commutator heating and armature heating. Poor flux distribution is caused by unequal air gaps, weak fields which do not keep the pole pieces magnetically saturated, or by defective field windings, all of which have been treated under other headings in this series.

Charles Proteus Steinmetz

(*Continued from page 596*)

introduction of alternating current apparatus.

"Steinmetz's practical inventions literally cover the entire field of electrical applications: Generators, motors, transformers, lightning arresters, lighting, heating and electrochemical operations. Of these many inventions, which were set forth in some 200 patents, perhaps the most important are the induction regulator, the method of phase transformation, as from two phase to three phase, and the metallic-electrode arc lamp. His experimental work in arc lighting led to the production of the magnetic arc. He devoted much time to the development of the mercury arc and by his masterly methods did much to improve this interesting and important type of illumination.

"Steinmetz was an ardent believer in the value of education. He not only found time to aid the educational work of Schenectady, but became president of the National Association of Corporation Schools, and lecturer at Union College. In a masterly address, upon retiring as president of the A. I. E. E. in 1902, he stated that all future progress in science and engineering depends upon the young generation, and to insure unbroken advance it is of preeminent importance that the coming generation enter the field properly fitted for the work. His personal example, his spoken words, and his writings have had a powerful and beneficial influence upon the development of the congenial environment and support necessary for a genius like his to develop to the fullest benefit of mankind.

"He was the author of many scientific papers and of a large number of electrical books which have been the accepted standards in colleges, laboratories and workshops everywhere."

* * * *

Charles Proteus Steinmetz, chief consulting engineer of General Electric Company, who died Oct. 26, was born April 9, 1865, at Breslau, Germany. He was educated at the University of Breslau, where he studied mathematics and astronomy, then physics and chemistry, and finally, for a short time, medicine and national economy. In 1889 he came to America, and secured a position with the Osterheld & Eichmeyer Manufacturing Company, Yonkers, N. Y., first as draftsman, then as electrical engineer and designer and finally on research work in charge of the Eichmeyer laboratory.

With the absorption of the Eichmeyer-Field interest by the General Electric Company, Dr. Steinmetz joined the latter and was attached to H. F. Parshall's calculating department in Lynn, Mass. With the transfer of the company's headquarters to Schenectady in the spring of 1894, Dr. Steinmetz organized and took charge of the calculation and design of the company's apparatus and of the research and development work.

For a number of years Dr. Steinmetz was professor of electrical engineering at Union College, and at the time of his death was professor of electro-physics at this institution, at the same time retaining his connection with the General Electric Company as chief consulting engineer, and about the year 1910 again entered into closer relation with this company by organizing a consulting engineering department under his charge.

In 1902, Dr. Steinmetz received the honorary A. M. degree from Harvard University and in 1903 the honorary Ph.D. degree from Union College. He was past president of

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the National Association of Corporation Schools, vice president of the International Association of Municipal Electricians, past president of the American Institute of Electrical Engineers, honorary member of the National Electric Light Association, past president of the Illuminating Engineering Society, fellow of the American Association for the Advancement of Science, member of the (British) Institution of Electrical Engineers, member of the American Mathematical Society, the Quaternion Society, the Society of Mechanical Engineers, the Electrochemical Society, the Illuminating Engineering Society, the Physical Society, and others. He was president of the Common Council and twice president of the Board of Education of the city of Schenectady.

Dr. Steinmetz was internationally known for his remarkable engineering achievements and original thinking on scientific subjects. Engineers everywhere have paid tribute to him as a man, a scientist and an engineer during his life time and since his death.

B. G. Lamme, chief engineer of the Westinghouse Electric & Manufacturing Company, revealed the human side of this man, not so commonly known, in the following statement after his death.

"As a personal friend, I knew him to be a witty, sociable man, and quite human in his dealings with his fellow men. The public, to which he was known as a man of mystery, would have found, as I did in personal contact, a real human being. Unlike many brilliant engineers, he left a record of his work in his numerous writings so that his contributions to science will live. He was a prolific writer on diversified subjects and his keen mind was no more clearly displayed anywhere than in his contributions to scientific journals."

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Aluminum Repairing—By Wm. H. H. Platt. Published by The Van Nostrand Company, 8 Warren Street, New York City, 70 pages illustrated, price $1.50.

This book takes up the repairing of aluminum sheet and castings and the attaching of copper, brass or steel to aluminum by tinning, sweating, and burning processes, by the use of sheet-iron jigs. Numerous illustrations with ample explanations show the methods to be adopted in working these processes. Those having occasion to make repairs or do construction work in aluminum will find this book a great help.

* * * *

Lighting Circuits and Switches—By Terrell Croft. Published by McGraw-Hill Book Company, 370 Seventh Avenue, New York City, 472 pages, 557 illustrations, price $3.

A practical reference book relating to electric lighting circuits and switches for interior building and industrial applications operating on low potential (less than 600 volts) systems. Most of the matter deals with 110-220 volt, two-wire and three-wire systems. The principal rules of the National Electrical Code which concerns the subjects under discussion, are interpreted as well as an explanation of how to comply with them.

The simpler circuits are explained and described in the book, but its most important function is to show diagrams and give descriptions of the more complicated circuits and control methods. These are the methods with which relatively few men are familiar and which are in any case easily forgotten. The work consists largely of diagrams and drawings which it has been endeavored to make self-explanatory. A closing chapter discusses circuits and gives complete specifications for the electric lighting of a modern theatre.

* * * *

Belt Conveyors and Belt Elevators—By Frederic V. Hetzel, member A. S. M. E. Published by John Wiley & Sons, Inc., New York City, 333 pages, 291 illustrations, price $5.

Men who have material to handle and who want to know more of the "how" and "why" of conveying and elevating machinery than is told in catalogs and advertisements of manufacturers, as well as engineers and draftsmen who have to advise in the selection or design of conveying or elevating equipment will find this book invaluable. In this book the whole field of handling materials with all its ramifications is not covered, but the use of belt conveyors and belt elevators for handling bulk or loose materials is treated exhaustively. Numerous examples are given of operating conditions which are used to illustrate the general principles underlying the design and use of conveying and elevating machinery. The whole subject is based on thirty years' experience in the designing and supervision of the erection and operation of this type of equipment. The auxiliary or accessory equipment of belt conveyors and elevators, such as belts, pulleys, idlers, chains, discharging and loading devices, in fact practically every phase of the subject is treated thoroughly.

* * * *

Stores and Materials Control — By Madison Cartmell, consulting industrial engineer. Published by The Ronald Press Company, 20 Vesey Street, New York City, 459 pages, price, $4.50.

Effective control of any industrial or commercial organization is usually based upon the control of the material handled. This covers the initiation of the order for the purchase or manufacture for stores, storekeeping, the issuing and filling of requisitions, including their delivery to the different divisions, and the final shipment of the product. This book explains in detail the procedure to be followed in an effective system of materials control in both large and small organizations and the basic principles and generally the practices applied to both alike.

A series of forms has been included which show plainly the steps in the necessary procedure and their interrelation. These illustrate both simple and complicated systems of material control operating under special conditions and so assist either the large or the small plant in applying these principles. A discussion is given on the physical handling and arrangement of materials as well as records which make possible adequate knowledge of location, quantity, and disposition.

* * * *

Economics of Electrical Distribution—By P. O. Reyneau, assistant electrical engineer, The Detroit Edison Company, and H. P. Seelye, distribution engineering department, The Detroit Edison Company. Published by McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City. First edition 205 pages, price $2.50.

The purpose of the book is to present the need for the application of economic principles to the design of distribution systems, to explain the fundamental principles involved, to indicate the type of problems most often encountered and to offer methods of studying such problems and reaching their solution. Practically all of this book is devoted to a theoretical discussion of the problems of electrical distribution and their practical application, although one chapter is devoted to mentioning some of the problems incidental to distribution in industrial plants.

* * * *

The Chemical Resistance of Engineering Materials—By Marston Lovell Hamlin and Francis Mills Turner, Jr. Published by The Chemical Catalog Company, Inc., 19 East 24th Street, New York, N. Y., 259 pages, illustrated, price $5.

Engineers and designers of chemical and other plants wherein acids, alkalis and corrosive liquids in general are handled, have frequent need of definite information regarding the effect of these liquids on the construction materials employed. Heretofore, the information has been scattered through various technical publications and hand- and text-books so that it was not readily accessible for reference. The authors have, therefore, performed a

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useful service in collecting together such information as is available in the literature. The aim of the book is: (a) to print the results of experiments and of general knowledge; (b) to serve as a bibliography of the subject by referring to all the sources used; (c) to stimulate further research by showing what parts of the field are incompletely covered.

Following the introduction in Chapter I, covering the general plan of work, classes of material, destructive reactions, and so on, Chapter II discusses sulphuric acid and its action on the various metals and alloys. Other chapter headings are: Other acids and metals; acids and non-metallic materials; bases and alkaline salts; neutral substances; selection of materials for specific equipment; concrete in chemical construction. The last chapter is an appendix containing a large number of useful tables, definitions, names and composition of alloys, physical properties of materials and so on.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

Minneapolis Electric and Construction Company, Minneapolis, Minn.—A folder describes a wire reel and meter for reeling and measuring wire and cordage of various sizes.

Torchweld Equipment Company, Fulton and Carpenter Streets, Chicago, Ill.—A new 40-page catalog, 23, describes this company's line of oxy-acetylene non-flash welding and cutting apparatus, lead welding, soldering, brazing and decarbonizing units, gas pressure regulators, automatic machines, generators, and other supplies. Cross-sectional views show the operation of both cutting and welding torches.

The Esterline-Angus Company, Indianapolis, Ind. — Bulletin 1023 entitled "Answers to Some Every Day Questions," contains five typical questions which might be asked in any industrial plant, with their answers. One of these questions, for example, is: "How can we tell how much it costs to overcome the friction load in our plant?" The other four are as interesting.

W. A. Jones Foundry and Machine Company, 4401-51 West Roosevelt Road, Chicago, Ill.—Catalog L-28 devotes 56 pages to data on "Lemley" friction clutches. In addition, price lists, dimensions, illustrations, horsepower ratings and other important data are given on sleeve clutches, cut-out couplings, clutch pulleys, ball-bearing clutch pulleys and gas engine clutch pulleys.

Midwest Steel and Supply Company, Inc., 28 West Forty-fourth Street, New York City.—A data book describes the use of "Midwest" steel sections for overhead shafting layouts and also for the anchorage of pipes, cables, machinery, monorails, car tracks, and various other equipment. This comprises a steel section which is embedded in the concrete ceiling, sidewalls or floor at the time of the construction of the building and serves to facilitate the erection of shafthangers, countershafts and other equipment.

The O. A. Olson Manufacturing Company, 706 Wilson Avenue, Ames, Iowa—Circulars describe the Ames lettering instruments used in lettering drawings.

The Autocall Company, Shelby, Ohio—A folder describes various types of Autocall equipment which is used for paging service, industrial fire alarm service, watchman's supervisory service, and in combinations of these.

Mercury Manufacturing Company, 4118 South Halsted Street, Chicago, Ill.—Bulletin 106 on "The Trackless Train" describes the Mercury Type H tractor. This tractor has an internal gear drive instead of a worm drive as has been used on previous models. This is claimed to give an increase of 25 to 35 per cent in efficiency. The power plant—the motor and driving gear—is assembled in a single unit which may be detached from the frame in five minutes.

Holophane Glass Company, 342 Madison Avenue, New York City — Bulletin 34-A entitled "The Holophane Lightmeter," gives a description of this instrument and instructions for its use in the measurement of foot-candles, lamberts, candles per square inch, candle power, coefficient of reflection, transmission factors, and for color matching.

The Leather Belting Exchange, 417-418 Forrest Building, 119 South Fourth Street, Philadelphia, Pa.—A 22-page booklet entitled "Making Leather Belts Endless," discusses in twelve chapters the steps in cementing the ends of leather belts. The points taken up are a discussion of the tools, making the laps, a study of the belts, and applying the cement. The material in this booklet has been published in INDUSTRIAL ENGINEER in the "Service Around the Works" Department but is placed here in a handy and convenient form for reference.

Reinforced Switch and Manufacturing Company, Inc., 400 North Avenue, Pittsburgh, Pa.—A folder describes "The Clip with a Grip," which is a reinforced clip for cartridge and knife-blade type fuses.

Link-Belt Company, Chicago, Ill.—"Silent Chain Data Book 125" discusses the design and construction of chains and wheels, gives instructions and tables for selecting, installing and lubricating drives, with numerous illustrations of drives in various lines of work in several industries. In addition a discussion is given of the use of silent chain and the advantages claimed for it over belts or gears.

Allan Manufacturing and Welding Company, Inc., Buffalo, N. Y. — A folder entitled "Electric Welding with Allan Polyphase," describes the use of alternating-current arc welders constructed for any primary voltage and number of cycles and making use of especially constructed transformers. A table gives the various types manufactured and the particular field to which each is adapted.

The Midland Dynamo and Motor Repairs Company. Ltd., Volta Works, 664 Belgrade Gate, Leicester, Eng.—A 16-page booklet describes the "Quickway" coil-forming machine and illustrates the various types of coils which may be formed on it.

Western Electro-Mechanical Company, Inc., Oakland, Calif.—A booklet entitled "Load Testing Device for A. C. and D. C. Circuits" describes and illustrates commercial testing devices for making electrical tests and measurements, phantom loads, load surveys, coils and windings and meter repairs.

The Formica Insulation Company, Spring Grove Avenue, Cincinnati, Ohio—A reprint of an article entitled "Study of Materials and Methods Needed in Non-Metallic Gear Production," gives a description of the use of Formica and special precautions to be taken when working it up.

The Cutter Company, 1819 Hamilton Street, Philadelphia, Pa.—A folder describes the I-T-E synchronism actuated lock-out feature for use in connection with starting and running switches for synchronous rotaries, to the end that the switch may be passed into the running position only when the rotary which it controls is in approximate synchronism with the system to which it is connected.

The Johns-Pratt Company, Hartford, Conn.—A booklet describes the "Noark" service box which is used as both a cutout and a switch, in one device. Also a number of conduit fittings for watertight service boxes are illustrated and described.

Lockwood, Eslick and Pfohl, Ellicott Square, Buffalo, N. Y. — A 4-page folder describes "Gardco" which is claimed to be an anticorrosive solution which prevents the rusting or corroding of iron, steel and zinc. It has the appearance of an enamel or paint and is claimed to resist the action of acid, fumes and brine and will not blister under heat. It is not affected by moisture, dampness, salt air, spray or sea water and has good electrical insulation properties. A number of suggested applications are included.

Jones, MacNeal and Camp, Inc., Warsaw, Ind. — A folder describes the "Power King" bench or post drill stand which gives the service of a portable drill and drill press from the "Power King" portable electric drill.

Stow Manufacturing Company, Inc., Binghamton, N. Y.—Leaflets G-3 and G-4 describe the Stow motor-driven grinders, buffers, drills and die-sinking tools. These are a portable, adjustable type of machine designed for a wide variety of work.

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Contents for December, 1923

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

D. H. BRAYMER, *Editorial Director*

Volume 81. *Number 12*

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Some Questions We've Been Asked

Are building repairs, improvements and plant safety included in the work of a maintenance organization?—In industrial organizations where plant service and maintenance is well organized the maintenance department includes distinct sub-departments or provides for the employment of men skilled in handling electrical installation and repair work, millwright work, carpenter, painting and masonry work, plumbing, ventilating and heating and machinery moving, trucking and janitor service. Such service the maintenance department is called upon to do in all departments of the works and it may include new additions, changes, inspections, overhauling and repairs so that machines and equipment engaged in production can be operated, with the fewest possible interruptions, at maximum output. The men engaged in production on such machines depend upon the maintenance organization to provide needed attention to their machines, aside from adjustments and setting up of operations, and in cases of trouble the maintenance men are called upon and expected to report in a hurry.

Building repairs, improvements and safety come under the head of plant service and the maintenance of set standards that include the maintenance of the physical condition of equipment and its housing facilities, which depreciate from natural wear and tear of production operations and from age. All of this work falls to the maintenance organization and where a definite organization is not provided, a certain few men are required to perform some or all the duties of the well-organized departments and in this respect these few men must be pretty much "jacks of all trades."

For instance, here is a typical list of jobs that came to the maintenance department of a certain plant in a single day:

Repair faucets and radiator in Building 15; repair two toilets and faucets in Section 3; install new light over timekeeping station; install starting box on power press; install swinging doors in store room; install gas burners in foundry; connect new motors in foundry; replace window panes in chemical laboratory; change wiring on power press motor; repair roof on foundry; install safety device on power press; put new caster on chair for auditor; replace shelves in laboratory; replace pinion gears on punch press motors.

INDUSTRIAL ENGINEER is devoted to the problems of those men who are responsible for operating and maintenance service for electrical and associated mechanical systems in mills and factories. And under maintenance is included the upkeep of buildings housing these systems and the standards set up for safety to operators and against fire. It does not deal with the individual problems of maintenance men who are the workmen and helpers, but with the problems of those men who analyze maintenance procedure and lay out the work for their assistants.—*Practical Pete.*

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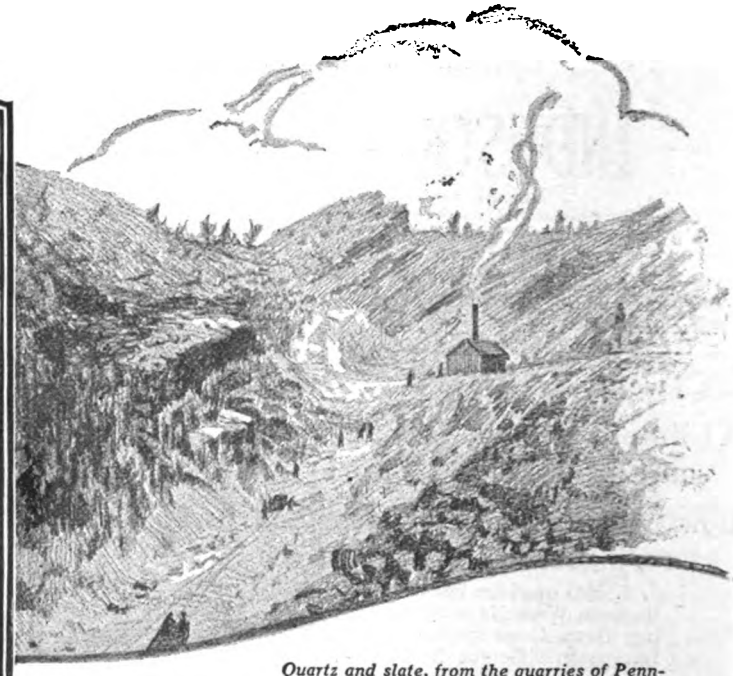
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Change of Address—When change of address is ordered the new and the old address must be given. Notice must be received at least ten days before the change takes place. Printed in U. S. A. Copyright, 1923, by McGraw-Hill Company, Inc. Published monthly. Entered as second-class matter Nov. 7, 1908, at the Post Office at Chicago, under act of March 3, 1879.

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Quartz and slate, from the quarries of Pennsylvania, are necessary ingredients as a filler for certain forms of electrical insulation

Quality Ingredients are Needed for a Quality Product

G-E insulating materials must be of the best in order to insure the dependability of G-E apparatus. To make these insulating materials superior in quality, no effort has been spared. For years the markets of the world have been combed for raw materials, and a capable laboratory staff has weighed, measured and tested every ingredient and every combination. The result is insulation of supreme excellence—worthy of incorporation into G-E apparatus.

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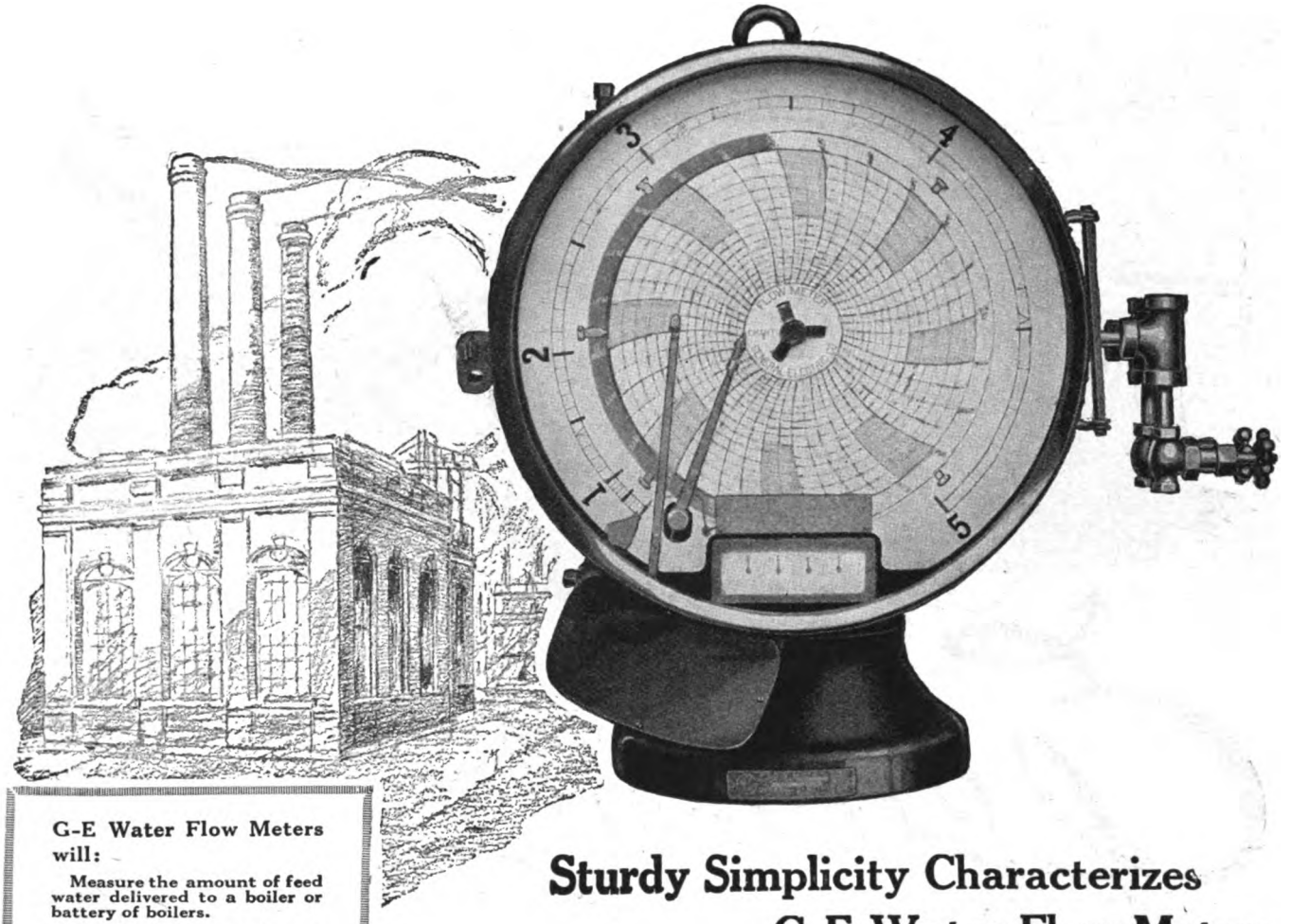


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G-E Water Flow Meters will:

Measure the amount of feed water delivered to a boiler or battery of boilers.

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Measure the total amount of water consumed by a municipality, or the amount distributed to different sections.

Measure the water input to water turbines thereby furnishing a means for determining their capacity and efficiency.

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G-E Water Flow Meters are simple in construction, easy to install and will measure satisfactorily the flow of hot or cold water for any purpose.

They register the total flow, indicate and record the rate of flow in pounds per hour, gallons per minute or boiler horsepower. These meters can also be supplied with temperature gauge recording temperature of water on the same chart with the flow.

Ask our nearest office for information about these meters.

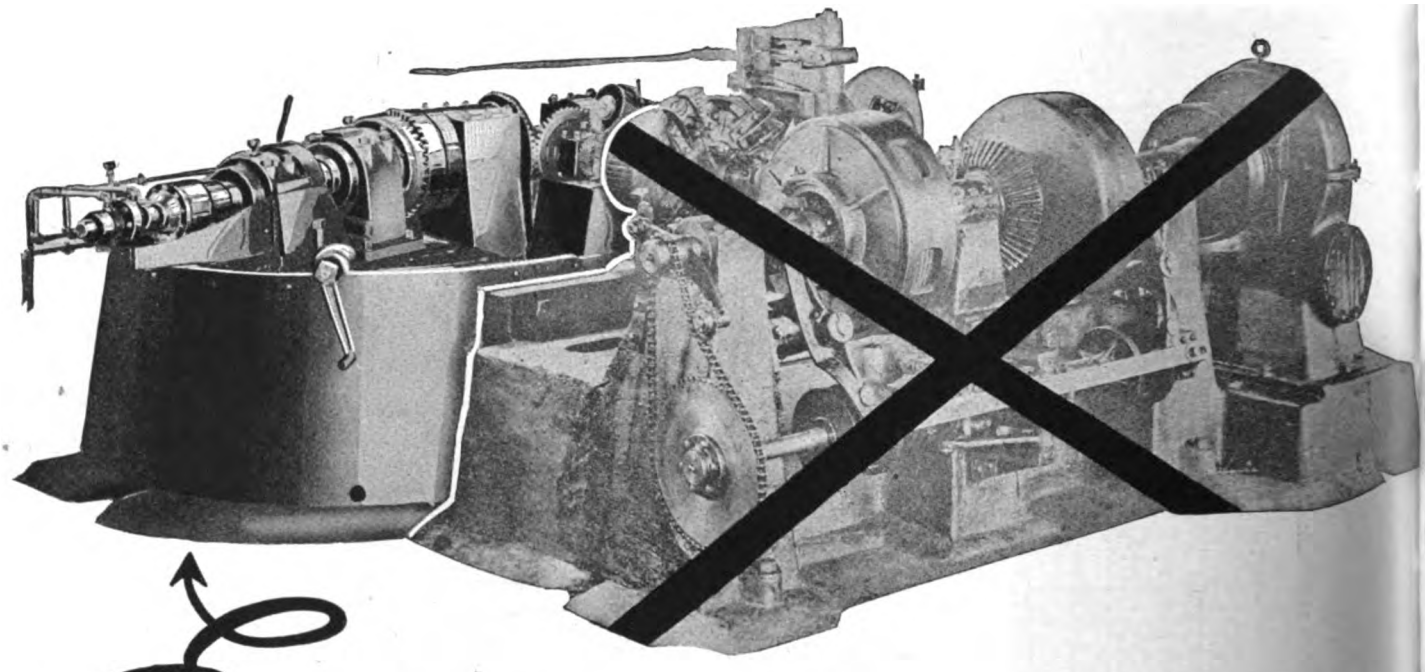
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The Anderson Rolled Gear Company had too much machinery in its old type of rolled gear machine. The picture above shows how much has been eliminated.

G-E engineers applied suitable control equipment to actuate a G-E direct-connected reversing motor—and the necessary reversing operation of the rolled gear machine became *electrical* instead of mechanical.

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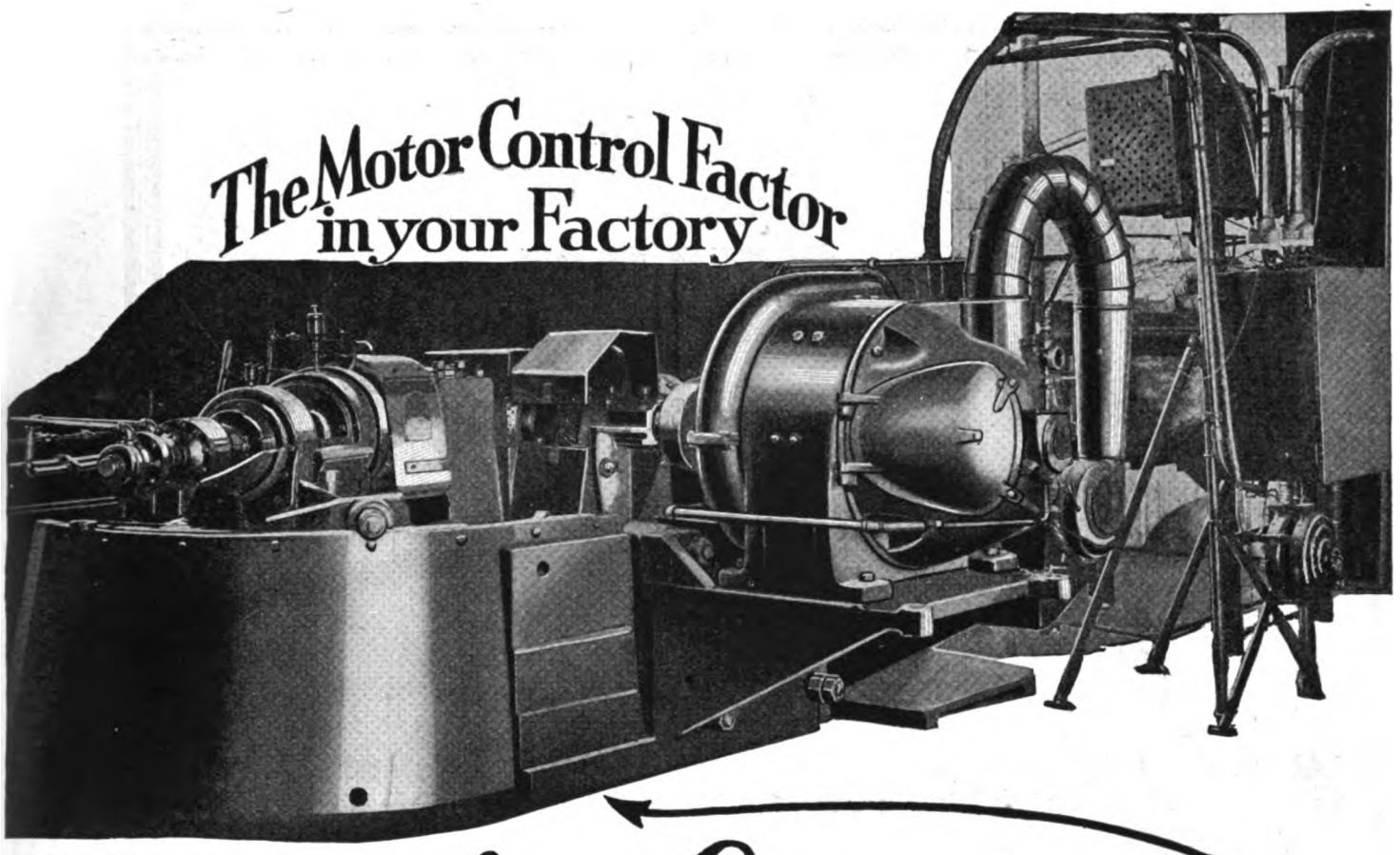
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Rolled Gear Company's machine secured these advantages:

Expensive, complicated mechanical drive parts of the machine were replaced by less expensive electric operating equipment — at a big net saving.

Cutting off the mechanical drive part of the machine eliminated the maintenance expense of frequent replacement of clutches, gears and bearings — worn by continuous reversing duty.

The application of complete electrical equipment to the machine reduced the power input from 90 Hp. to 9 Hp. — and a 17½ Hp. motor replaced the 125 Hp. motor hitched to the old mechanical drive.

It is worth while to *simplify*. G-E engineers will gladly co-operate with you in improving your machinery by suitable application of electrical equipment.

Broad experience in supplying Industrial Control Equipment for diversified motor applications places the General Electric Company in a position to meet your requirements — readily.

General Electric Company
Sales Offices in all Large Cities

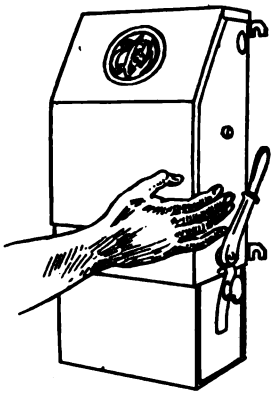
43A-94

ELECTRIC

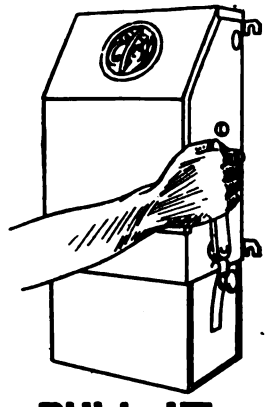
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IT'S EASY TO START

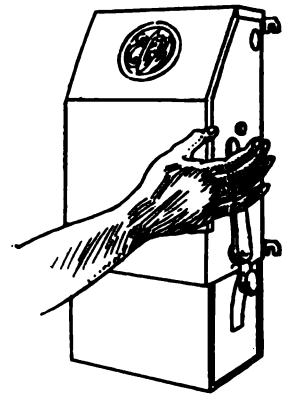
THE TYPE ZK MANUAL-AUTOMATIC COMPENSATOR



TAKE HOLD OF THE HANDLE

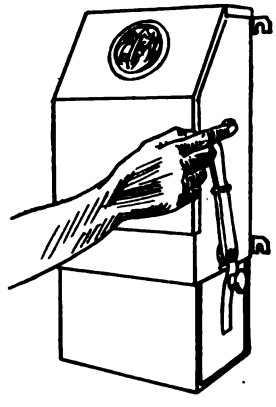


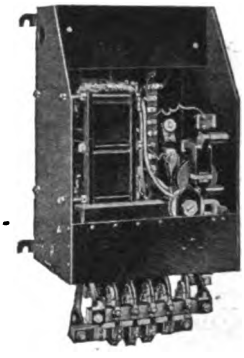
AND PULL IT TOWARD YOU



THEN IMMEDIATELY LET GO







TO STOP PUSH THE BUTTON

The Type ZK Manual-Automatic Compensator for starting and stopping A. C. Motors is easy to operate. It automatically thinks for the operator who has only to pull the handle to connect the motor through the transformers to the line and start it. Then as soon as the motor has reached the proper speed, the Compensator automatically throws it across the line. To stop the motor it is only necessary to push the button above the handle.

The Compensator provides inverse time element overload protection while starting and while running, and protects the motor against lost phase and no-voltage.

Write for Bulletin 1046

THE ELECTRIC CONTROLLER & MFG. CO.

BIRMINGHAM-BROWN-MARX BLDG. CHICAGO-CONWAY BLDG. CINCINNATI-FIFTH NATIONAL BANK BLDG. DENVER-3535 WALNUT ST. DETROIT-DIME BANK BLDG.

CLEVELAND, OHIO

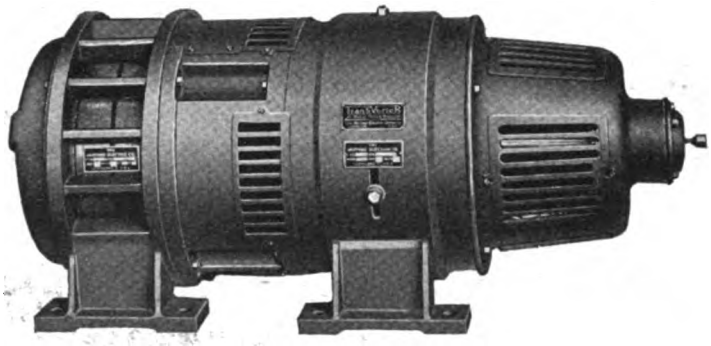
LOS ANGELES-O.E. THOMAS CO. BOSTON-49 FEDERAL ST. NEW YORK-50 CHURCH ST.

PHILADELPHIA-WITHERSPOON BLDG. PITTSBURGH-OLIVER BLDG. SAN FRANCISCO-CALL BUILDING SEATTLE-524 1ST AVE. SOUTH TORONTO-TRADERS BANK BLDG.

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Vertical Ball Bearing
AC to DC
Motor Generator
Sizes 1 to 10 KW

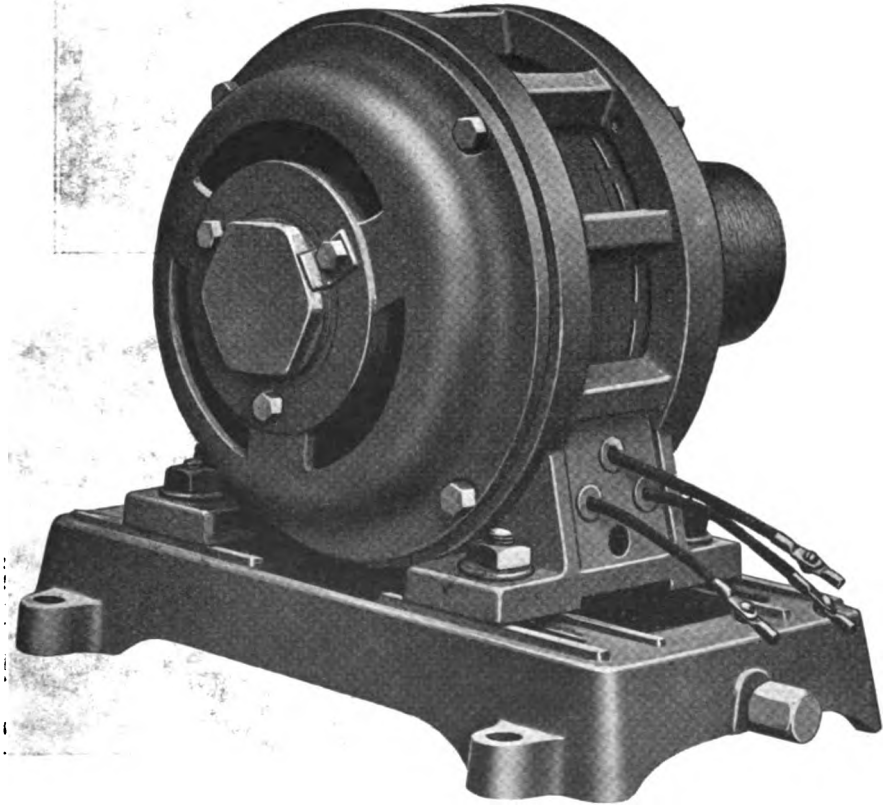


Horizontal Ball Bearing
AC to DC Motor Generator
Sizes 3 to 17 KW

Motor Generators that are built to furnish Direct Current of any volt-ampere characteristic that is most suitable for the service. Built either Horizontal or Vertical and Ball Bearing. Used by such Companies as—

AMERICAN RADIATOR COMPANY
HOLT MANUFACTURING COMPANY
INDUSTRIAL TRUCK COMPANY
BAKER R & L COMPANY
and

Backed by many years experience. Statements that *talk*.



40° Polyphase Induction Motor, Ball Bearing, Size ½ to 50 H. P.

Hertner Induction Motors have many factors that recommend them, such as—

Safety
High Power
Perfect Lubrication
Well Ventilated

We stand ready to show you why our motors give satisfaction to thousands of users over a period of many years.

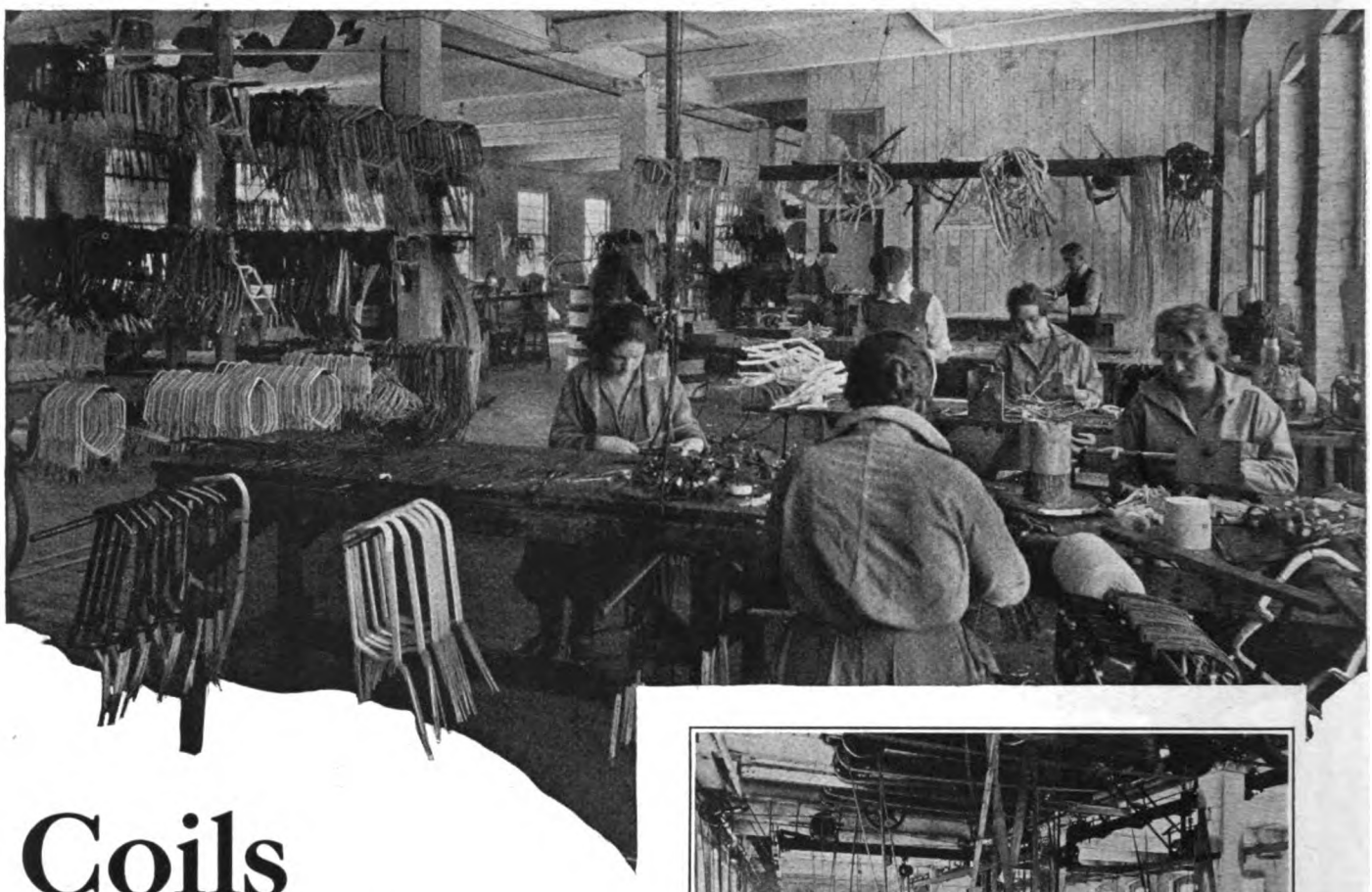
Write for Bulletin 10A.

The Hertner Electric Co.

W. 112th St.
CLEVELAND, OHIO

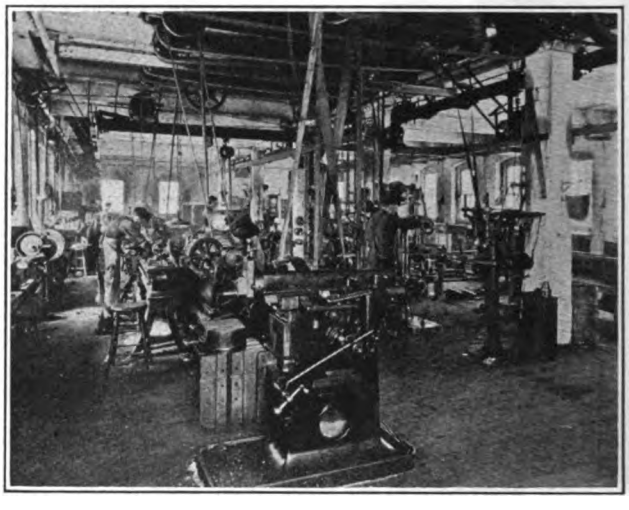
Rochester, N. Y. Detroit, Mich. Chicago, Ill.
St. Louis, Mo. Rockford, Ill.

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Coils
for production

Electrical equipment manufacturers will do well to get sample coils and prices for their products. This company is now turning out thousands of coils weekly on a production basis. It costs nothing to check up. Drop us a line with a blue print or send sample coil.



Coils for maintenance

For years, I. R. Nelson Co. has supplied many of the leading steel, iron, copper, zinc, tin and other metal working industries with new coils for maintenance. Tell us of your requirements.



Service to Industry

Our emergency service will undertake any repair, large or small. A force of from 1 to 10 men can leave Newark within 2 hours after receipt of wire or phone message.

Get in touch with us. We shall be glad to serve you.

I. R. Nelson Co.
Bond Street
Newark, New Jersey

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In the Shop

You need good machines and good men in the Shop. Both bring big money. Neither is of any use without good lighting.

Good lighting depends upon good wiring devices. A good wiring device gives uninterrupted service for years and years. A poor wiring device gives trouble.

Even a good wiring device costs only a few cents. A poor wiring device costs a few fractions of a cent less.

Think a moment: when you try to save a few cents on wiring devices that are not as good as Bryant you may be making trouble and expense that runs into thousands of dollars of lost productive time. Where is the saving?

There are two outstanding reasons for the known superiority of Bryant Wiring Devices.

One is: we want to make them better than any others.

The other is: thirty-five years of experience have taught us how to do it.



No. 2597
with Cast Cover

No. 1924

This is one of a series of advertisements depicting the scope of service rendered by Bryant Wiring Devices

BRYANT

"A Superior Wiring Device for every Electrical Need"

THE BRYANT ELECTRIC COMPANY
1421 STATE ST., BRIDGEPORT, CONN.

NEW YORK
342 Madison Ave.

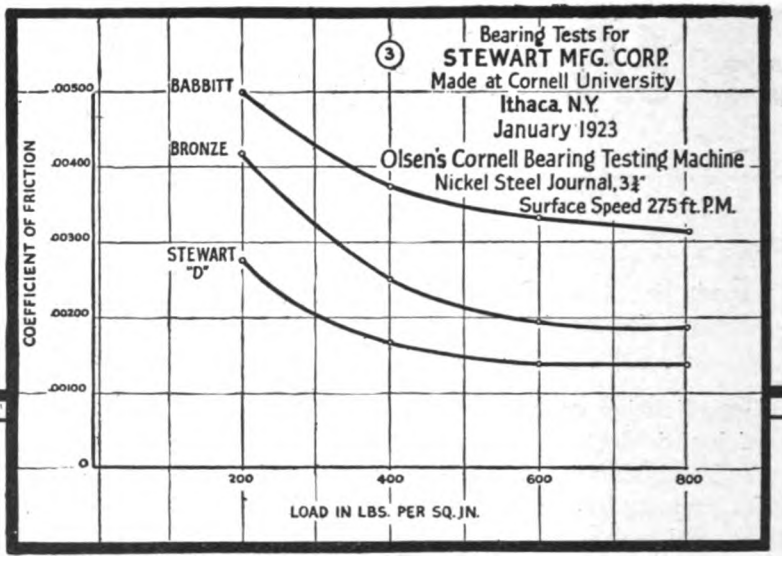
CHICAGO
844 West Adams St.

SAN FRANCISCO
149 New Montgomery St.

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This chart shows the results up to a pressure of 800 lbs. per sq. in. of a test conducted by Professor W. M. Sawdon, of the College of Engineering of Cornell University.

A high grade mineral oil was used as lubricant, applied to bottom of the shaft. Lubrication and all other conditions were the same for each metal. The bearings were put on, one at a time, and thoroughly worn in. The friction and temperature rise of each metal under each load were noted and plotted. The result was a remarkable demonstration of the bearing quality of Stewart Brons Metal.



Are You Buying Bearing Quality?

Add an inch and save 2

The ordinary bar of bearing metal is 12″ long. Stewart Brons Bar is 13″ long machined all over. That extra inch gives you 12 full inches of bearings with ample room for tool clearance and chucking; saving besides the labor and overhead of machining.

The average saving for every user of Stewart Brons is about 50% of the bearing metal, and a big saving in bearing costs.

LOOK over the plotted result of this remarkable bearing metal test. Made by a disinterested scientist, it is conclusive evidence that Stewart Brons is the *perfect* bearing metal; that Stewart has discovered the long sought secret — the perfect amalgamation of copper and lead in any desired proportion.

Consider what that means; as this competitive test proves, to users of bearing metal! *Now*—with the advent of Stewart Brons — you get the best bearing quality known.

[1] Stewart Brons. Provides remarkable bearing quality through an unusually low coefficient of friction.

[2] Its melting point is 1700° F.; remember ordinary babbitt melts at 400° F.

[3] At 600° F. it sweats a little lead and so lubricates itself should lubrication fail.

[4] Will not burn out or score a shaft up to 1000° F.—is uniform in texture; the interfusion of copper and lead makes it homogeneous; the union of the metals become seven closer with successive remeltings.

Stewart Brons Metal is made in four grades: "B" 25 Brinell; "C" 40 Brinell; "D" 50 Brinell; "E" 80 Brinell [a special metal for heavy service]. 258 stock sizes of bars and bushings, 13″ lengths, finished all over.

Our proposal to jobbers is very attractive. Write for details.

STEWART MANUFACTURING CORPORATION
4509-92 Fullerton Avenue Chicago, Illinois

Or communicate with our nearest factory representative

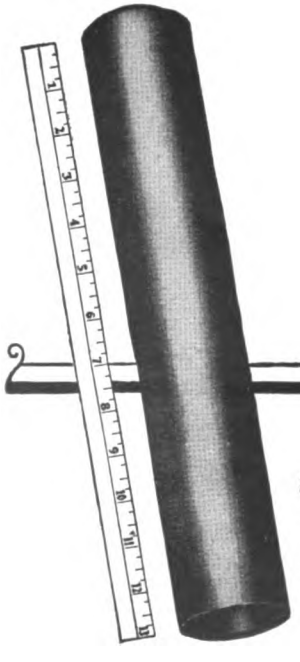
L. RUPRECHT
30 Church Street
New York, N. Y.

A. C. OLFS
7321 Woodward Avenue
Detroit, Mich.

C. W. ROOT
57 Erie Street
Milwaukee, Wis.

J. FRANK LANNING & CO.
327 First Avenue
Pittsburgh, Pa.

E. P. GRISMER
1986 E. 66th Street
Cleveland, Ohio



Stewart Brons Bearing Metal
The Perfect Metal for Bearings

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He doesn't sell them to you, he buys them for you

Look on the Western Electric motor dealer in your town as your expert representative, ***buying for you.***

He knows motors and has gone over the field with thoroughness before he recommends any type for your use. He studies your needs and equips himself to fill them.

This dealer carries stocks to meet ordinary requirements. For more special demands he can call on a nearby Western Electric House.

A NATIONAL ELECTRICAL SERVICE

Western Electric Company

OFFICES IN ALL PRINCIPAL CITIES

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THE ARRO-GRIP CAP
FOR PENDENT SOCKETS ON INDUSTRIAL PENDENT WORK

Another Reason for Standardizing on Arrow Sockets



This wouldn't have happened with ARRO-GRIP



Note the insurance against wire troubles with ARRO-GRIP



A and AA



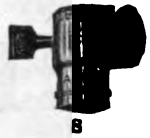
R



C



No. A-62



S



D and DD



T

Any Arrow Socket Body will take No. 62 Arro-Grip Cap. Use Arro-Grip Sockets for industrial pendent work to prevent fraying and pulling away of wires from binding screws.

Send for New Arrow Catalog



W



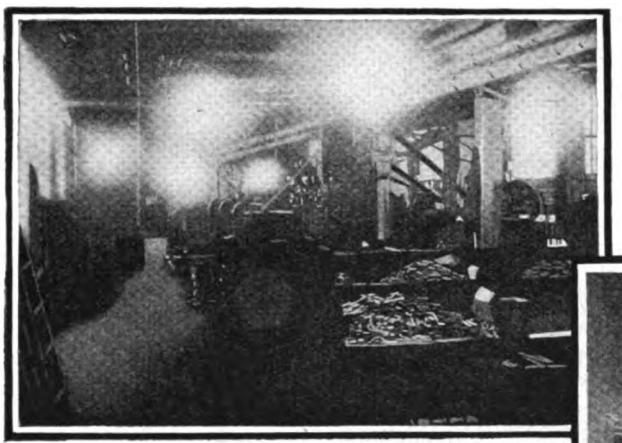
F and FF

THE ARROW ELECTRIC COMPANY
HARTFORD, CONNECTICUT

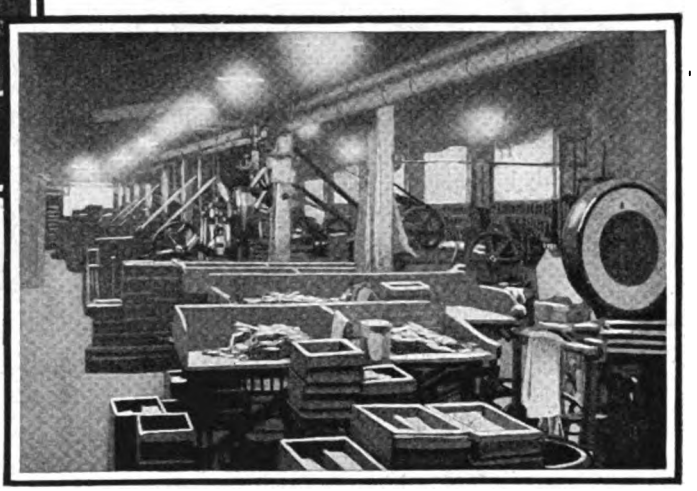
ARROW

The complete line of Wiring Devices

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"Before and After" Lighting



Previous to re-lighting, this plant used bare, unshielded lamps of various sizes, scattered at random. In the new installation, bowl enameled MAZDA C Lamps in RLM standard dome reflectors are symmetrically spaced and hung at the correct height. It is quite apparent why production is increased.

THE PICTURES above were taken in a silverware factory. But consider such widely diverse products as breakfast food, men's collars and talking machines.

That lighting is a powerful factor in the efficiency of *any* plant, is shown in these letters — quoted from the many that are received by our Lighting Service Dept.

From The Shredded Wheat Company

Our superintendent reports most gratifying results from the use of your lamps and the lighting systems installed in our Buffalo Ave. and Erie Ave. plants.

The lamps are certainly better for our purpose than any we have formerly used, and there is no doubt that the improved lighting has given us greater production and a more uniform product.

With better lighting there is naturally less spoilage and waste—and less eye-strain; a fact that induces higher efficiency and better morale.

A. J. PORTER, *President*

From The Victor Talking Machine Co.

We have devoted considerable time to the study of lighting, from which we have drawn the following conclusions:

1. Proper lighting is a distinct aid in securing production and has a favorable effect not only on quantity but also on accuracy.
2. Good lighting is perhaps the first thing to be considered in safety work.
3. In sanitation we find that it pays to be liberal with light.
4. Morale of our working force is strengthened by the psychological effect of well-lighted surroundings.

A.W. ATKINSON

From Cluett, Peabody & Co., Inc. ("Arrow Collars")

In order to produce the highest quality of work in the most efficient manner, it is of first importance that illumination be given to all parts of our plants.

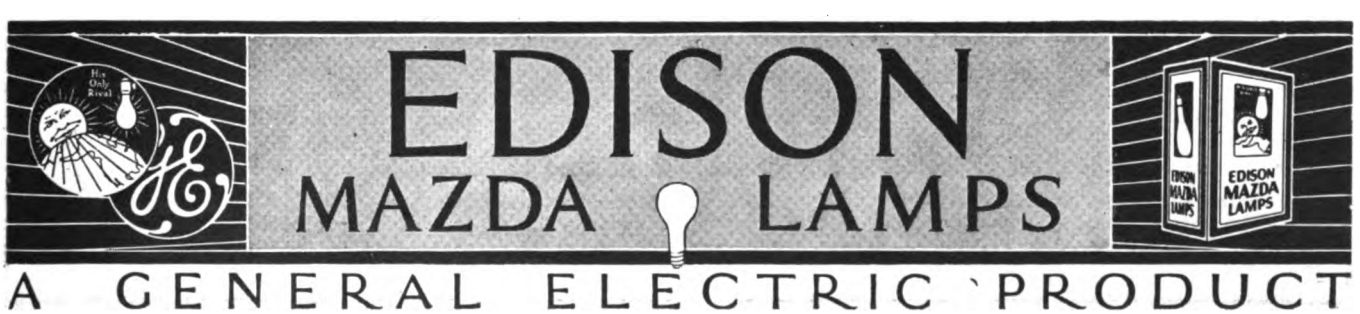
Protection of employees' eyesight, and agreeable and pleasant working conditions, mean that much more light must be supplied than is sufficient merely for safety.

There must be no shadows, no reflections, and no glare—and all work and inspection must be illuminated so as to show the slightest flaw.

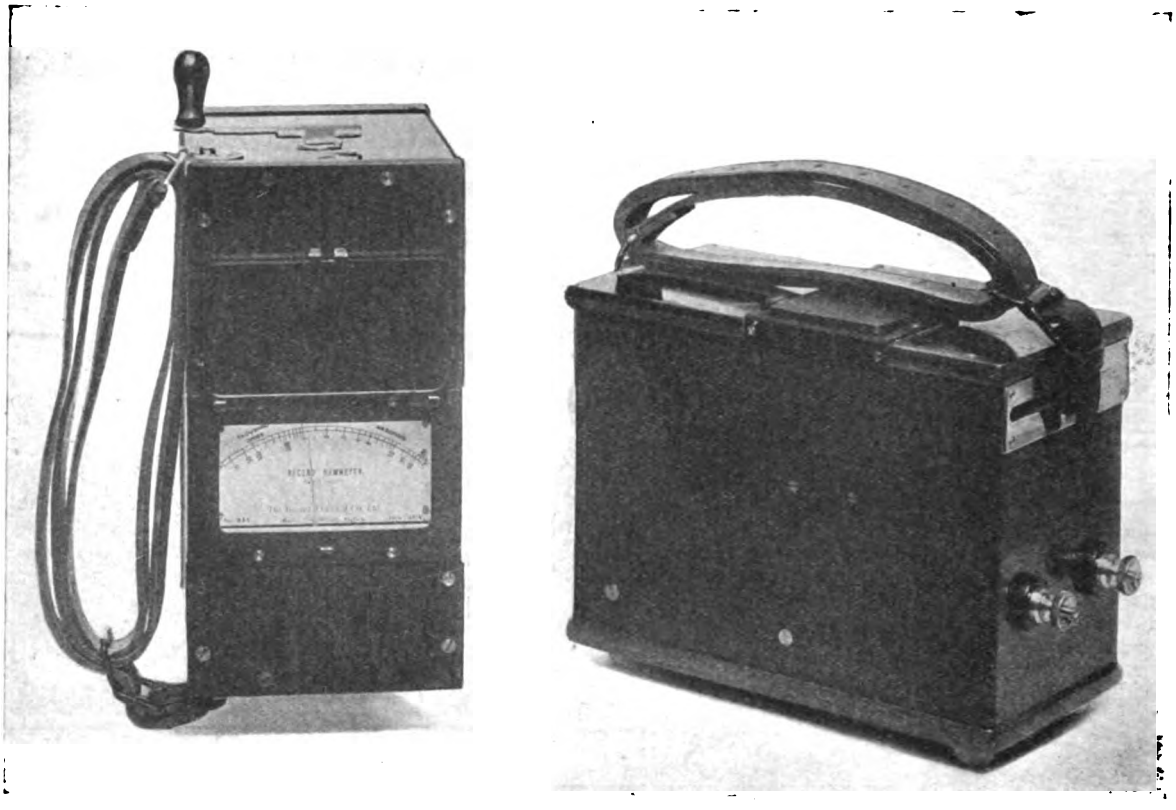
Good lighting pays a very handsome return on the money invested.

SANFORD L. CLUETT

THE MAKERS of the famous Victrola recognized the value of light after "considerable time devoted to the study of lighting." With the special booklet we have prepared on your particular kind of business, considerable time is not needed—we have done the studying for you. The booklet will be sent without obligation, if you write, mentioning your kind of business, to The Lighting Service Department, Edison Lamp Works of General Electric Co., Harrison, N.J.



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CORY-RECORD OHMMETER

Electrical Engineers

Who believe in making insulation resistance tests will appreciate the value of the CORY RECORD OHMMETER.

The Ohmmeter is so light in weight and easy to operate that the most unskilled electrician can safely and accurately test your telegraph, telephone and power cables, interior wiring, feeders, switches, switchboard circuits, rotating electrical machinery, transformers, line insulators, etc.

It will increase your plant efficiency by helping to cut down expensive delays caused by faulty insulation conditions.

Write today for Catalog Bulletin 101-29-C and learn more about this valuable instrument

CHAS. CORY & SON Inc.

Cory Building, 183-187 Varick Street, New York

BOSTON PHILADELPHIA SAN FRANCISCO

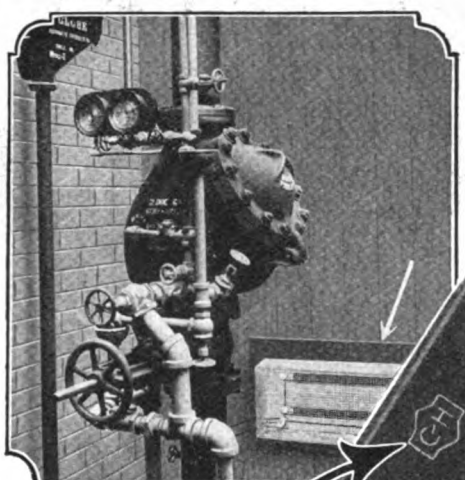
CHICAGO
Alberger Pump & Condenser Co.
22 West Monroe Street

ST. LOUIS
Reeves & Skinner Machinery Co.
2211 Olive Street

SEATTLE
W. S. De Pierris Co.
Hoge Building

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Two C-H Space Heaters in Sprinkler System Valve House.

Do You Want to Heat Your

Sprinkler System Valve House?

Your Crane Cab?

Your Japanning Ovens?

Do you want to apply heat for some manufacturing process; such as the warming of Bakelite or similar products before punching to prevent cracking of edges; do you want to prevent fuel oil from thickening; heat asphalt kettles; prevent condensation of moisture in pits and on underground electrical equipment? Several hundred thousand C-H Electric Space Heaters are in use for these purposes —over 2000 in one plant alone.

Used in negative drying cabinet.

All these and 100 other applications are described in our booklet, "Dictionary of Uses"—all actual applications as told to us by users.

C-H Electric Space Heaters are so easily installed—they are flat—2 feet long—like a ruler with insulated mounting eyelets on either end. They may be connected to lighting or power circuits—take no more current than an ordinary household electric iron or toaster.

Space Heaters were developed by the same engineers who developed the numerous C-H products—men responsible for the application of electric heat to linotype pots, electric ranges, embossing press blocks, package sealing machines, soldering irons, glue pots, and many other industrial equipments.

Carried by electric supply houses everywhere — $3.00 each (East of the Rockies)—less in quantities. Order a carton of 10 today—a copy of "Dictionary of Uses" is enclosed.

C-H Space Heaters replaced steam bath in cafeteria serving counter.

THE CUTLER-HAMMER MFG. CO.

Industrial Heating Department

Works: MILWAUKEE *and* NEW YORK

Offices and Agents in Principal Cities

Northern Electric Co., Ltd., Can.



Send for this 64-page "Dictionary of Uses"

C-H CUTLER-HAMMER

SPACE HEATERS

"TWO FEET OF ELECTRICAL HEAT"

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3 Inches in a Minute



Can you do this?

Do you know of an electric hammer-drill that will go through a three inch concrete slab in one minute? The SYNTRON will.

The lightest electric power hammer and drill on the market, it has only one moving part, makes 3600 strokes per minute and is impossible to get out of order. It can be attached to any electric light socket.

Furnished complete in cases for carrying, with an assortment of tools for all types and sizes of work.

This hammer is a necessity where any amount of chipping or drilling is done. We can prove it in dollars and cents. *Write for details.*

Fill out and mail the coupon, today, for prices and complete description of the Syntron Electric Hammer.

Three Types

Type F-Weight 9 Pounds
Capacity ⅝ inch

Type A-Weight 17 Pounds
Capacity 1 inch

Type B-Weight 26 Pounds
Capacity 1⅝ inch

For

Drilling through masonry walls
Drilling holes for expansion bolts
Chipping and cracking stone
Chipping metal and castings
Driving rivets
Light assembly work of all kinds
Squaring or breaking up stone and pavements
Calking pipes, tanks, plates, etc.
Vibrating
And any purpose where the rapid strokes of a hammer can be used

National Electric Mfg. Co.,
650 Chatfield & Woods Bldg.
Pittsburgh, Pa., U. S. A.

Gentlemen:
Please send me, without obligation on my part, catalog and prices on the Syntron Electric Hammer.

Name ..... Title

Company .....

Address .....

City ..... State .....

National Electric Mfg. Co.

650 Chatfield & Woods Building, Pittsburgh, Pa.

Sales Offices in Principal Cities

SYNTRON Electric Hammer

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This Sample of the Ultimate Fuse Speaks for Itself





The sample will tell its own story of:

Time saved in renewing because of few and simple parts—only three and the renewal link.

No searching for parts lost or misplaced because there are no small loose parts.

Time saved in getting back into service quickly machines shut down because of the blowing of a fuse.

No more faulty renewals. You cannot put the BUSS Knife Blade Type Renewable Fuse together in the wrong way.

Long life because of sturdy construction and positive venting paths.

Fill in the coupon and mail it now

BUSSMANN MFG. CO.
St. Louis, Mo.

IE. 12-23

BUSSMANN MANUFACTURING CO.
3819 North Twenty-Third Street, St. Louis, Mo.
Without obligation, send me for examination sample 100 ampere, 250 volt Knife Blade Type BUSS Renewable Fuse.

Name
Position
Company
Street
City
State

BUSS FUSES

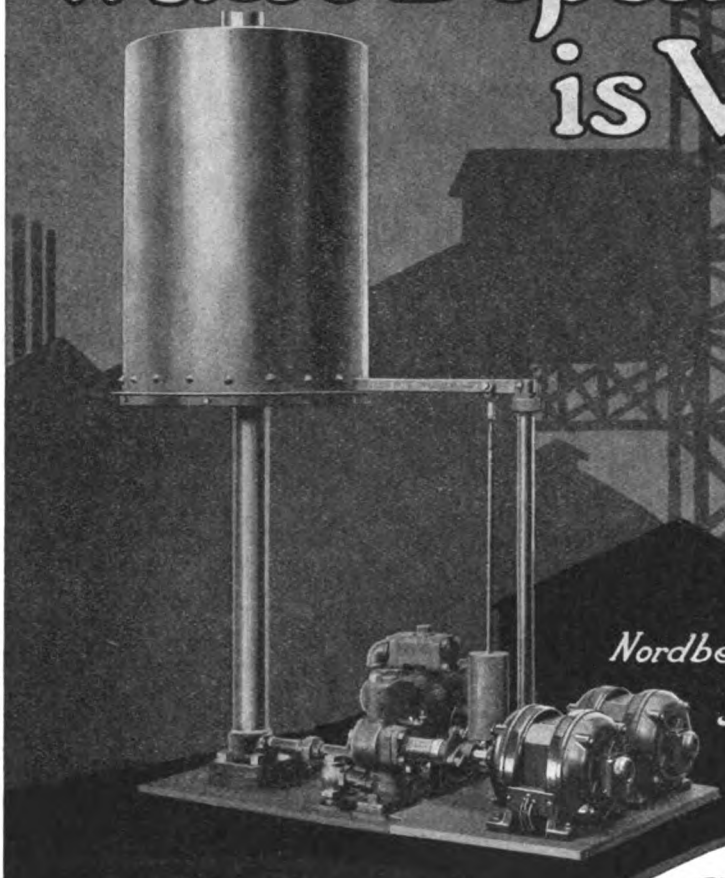
APPROVED IN ALL TYPES AND SIZES

TRADE Buss Fuses ELECTRICITY'S SAFETY VALVE MARK REG. U.S. PAT. OFF.

"ELECTRICITY'S SAFETY VALVE" MEANS ON

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Where Dependability is Vital



Nordberg Accumulator for electric hoist control equipped with

Louis Allis
Heavy Duty
Type H.D. Motors





The Indestructible Rotor

of the "Louis Allis" type H. D. Motor eliminates uncertainties in the application of power, and assures the continuity of service, so vitally essential to the operation of hoisting machinery.

"L-A" Motors are the specified drive for the oil pumps of the Nordberg Accumulator. This device gives absolute and complete control over the brakes and clutches of the hoist. Its operation must therefore be positive and unfailing.

Mechanical infallibility is the prime objective sought in its design and construction and L-A Type H. D. Motors are relied upon accordingly.

THE LOUIS ALLIS CO.

formerly THE MECHANICAL APPLIANCE COMPANY

ESTABLISHED 1901

MILWAUKEE, WISCONSIN

L-A Motors

Watson Motors

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World's Largest Single Enclosed Space

Heated with Skinner Bros. (Baetz Patent) Heaters

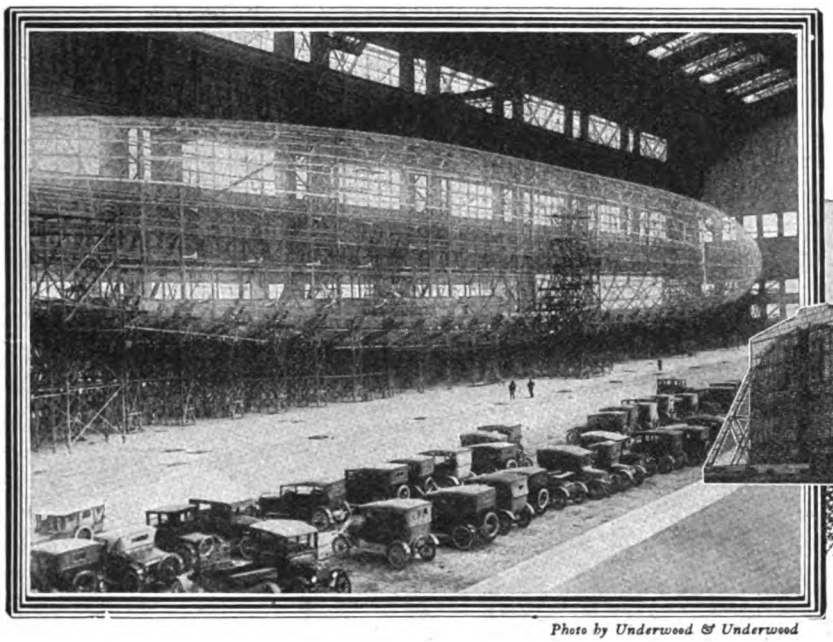


Photo by Underwood & Underwood

This shows the interior of the enormous Naval Hangar at Lakehurst, N. J.— heated with Skinner Bros. (Baetz Patent) Heaters.

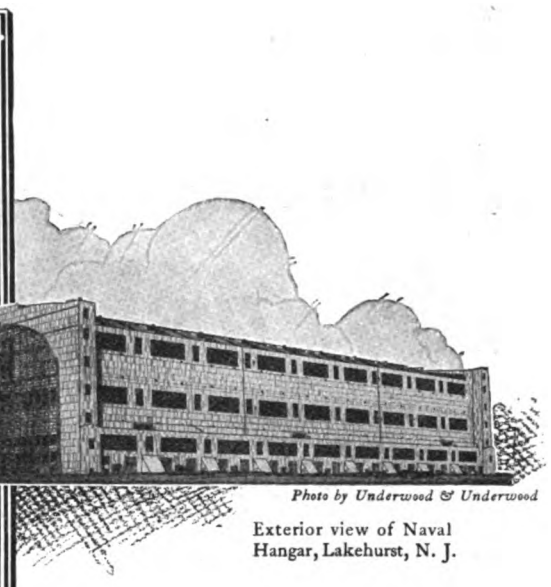
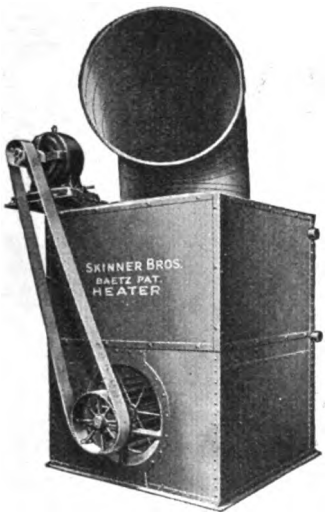


Photo by Underwood & Underwood

Exterior view of Naval Hangar, Lakehurst, N. J.



Steam coil type SC. Uses live or exhaust steam. Where steam is not available, we supply Direct Fired type DF. Burns coal, coke, wood, gas or oil.

The Naval Hangar illustrated above contains 57,000,000 cubic feet of air and is properly heated by only 16 Skinner Bros. (Baetz Patent) Heaters! The significance of this statement will be more apparent when it is pointed out that each of the Skinner Bros. (Baetz Patent) Heaters used is smaller than a Ford touring car.

This is only one instance where the superiority of Skinner Bros. (Baetz Patent) Heater has demonstrated itself—among many highly satisfied users are such firms as General Motors Corp., International Shoe Co., Ozark Theatre, Federal Foundry, Quick Meal Stove & Range Co., Ford Motor Co., United Paperboard Co., and hundreds of others, large and small.

Built on an Entirely Different Principle

The Skinner Bros. (Baetz Patent) Heater is built on a principle totally different from old style apparatus. It uses no pipes or ducts as warm air carriers yet it thoroughly warms every part of the open area in a building. Due to special design, it can also be used as a ventilator and air conditioner—operates economically both summer and winter.

Get full details—ask for catalog E-9 and full list of users.

SKINNER BROS. MFG. CO., INC. Main Office and Factory: 1474 S. Vandeventer Av., St. Louis, Mo.
Eastern Office and Factory: 140 Bayway, Elizabeth, N. J.

Boston, 445 Little Bldg. Buffalo, 702 Morgan Bldg. Chicago, 1703 Fisher Bldg. Cleveland, 612 Marshall Bldg.
Cincinnati, 1050 Hulbert Bldg. Wash., D. C., 714 Evans Bldg., Phila., Pa., 1711 Sansom St.
Oliver Schlemmer Co. U. D. Seltzer Haynes Selling Co.
New York, 1702 Flatiron Bldg. Pittsburg, 8 Wood St., Pittsburg Heating Co. Spokane, 409 First Ave., H. B. DeLong Co. Detroit, 308 Scherer Bldg.

SkinnerBros.

Baetz Patent HEATING SYSTEM

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Oil--
Nails--
Screws--
Washers--

--all are accounted for--

Why not Energy?

Competition and modern business methods demand of the manufacturer an accurate knowledge of what his products cost him. An essential part of the cost of any manufactured product is the expense of the power used in producing it. It takes a certain amount of energy to perform a given operation and POWER COSTS MONEY—it enters into the cost of production just as much as material and labor.

A watthour meter installed on each department or major operation will greatly increase the accuracy of the cost system and the Duncan watthour meter because of its high initial and sustained accuracy in service, its long life and ease of adjustment and freedom from repairs is admirably suited to the requirements of such service. Write for bulletins.

Duncan Electric Manufacturing Co.

Lafayette, Indiana

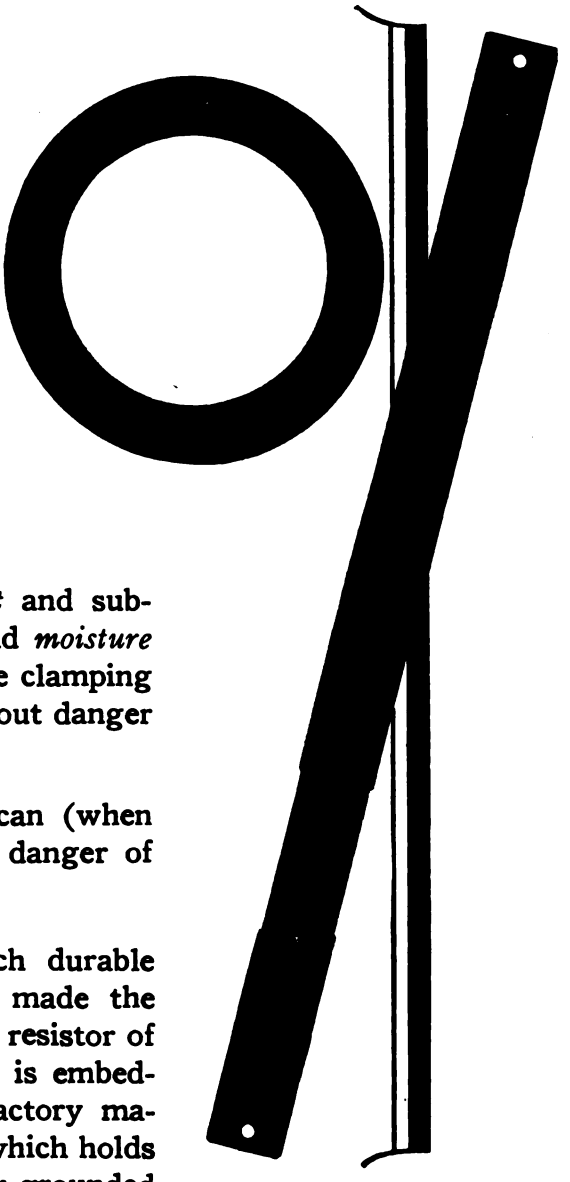
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Can you overload the heater you are now using 500% without damage?

On repeated tests by interested parties the 2-foot 500 watt "Chromalox" Strip Heater has withstood over 600% rated input without damage. Voltage variation therefore has no damaging effect on these heaters.

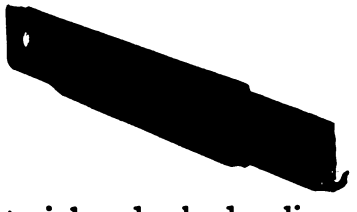
They can be supplied in standard overall lengths of 12", 18" and 24" for voltages ranging from 55 to 250 and wattages to meet your specifications. A "strip of heat" for every purpose.

Lengths up to 6 feet can be supplied on special order.



"Chromalox" Strip Heaters are *light in weight* and substantially constructed — being *completely enclosed* and *moisture proof*. The terminals are on one side, permitting the clamping of the heater to smooth surfaces when desirable without danger of grounding.

They are ground tested on 1100 volts. They can (when conditions permit) be operated at 1400° F without danger of destroying the heating element or terminals.



The reason for such durable units is that they are made the "Chromalox" way. The resistor of nickel chromium ribbon is embedded edgewise in a refractory material under hydraulic pressure of one hundred tons which holds the resistor rigidly in place preventing open, short or grounded circuits.

Place a trial order today. If your electric supply house does not have them in stock, write direct and we will see that you are supplied.

Booklet (F-10-I) and price list will be sent at your request. Fill out the coupon and mail today.

CHROMALOX

Trade Mark Reg. U. S. Pat Off.

"The Mark That Identifies"

Edwin L. Wiegand Co.

422 First Avenue

Pittsburgh, Pa.

Edwin L. Wiegand Company, 422 First Avenue, Pittsburgh, Pa.
Please send me booklet (F-10-I) on "Chromalox" Strip Heaters.

Name..... Company.....

Address..... City.....

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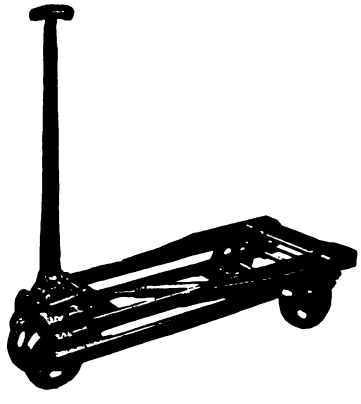
Stop up the profit-draining hole of manual load handling

FOR example, it made it possible for one concern to effect a 43 per cent reduction in handling costs.

Many executives have, unexpectedly, found a surprising number of these "holes," through a casual stroll through the shop or warehouse.

Here, two or three men loading a factory truck—when one, with the proper equipment, could do the work. There, five, six or more rehandlings of materials on their way through progressive manufacturing operations and storage —though all could be easily eliminated.

Cowan Hand and Electric Lift Trucks and Cowan Skids Cut Handling Costs



Cowan Hand Lift Truck. Powerful and easy lift. Positive lock. Moves with little effort. Cowan special unloading device. Automatically adjusting check. Alemite lubrication.



Cowan Electric Elevating Truck. Powerful Motors. Positive braking and control. Anti-kick steer. Capacity. Absolute dependability. Speed of operation. Alemite System properly applied.



Cowan Long Life Skid. Strength. Rigidity. Long Life. Price consistent with quality Remember price must include future maintenance costs.

The Cowan Truck Company offers you the most economical equipment you can purchase, not always in price but in the thing you really pay for—results.

We have a Bulletin devoted to your particular business. Send for it.

We call your attention to our Custom Department for your trailer and special problems.

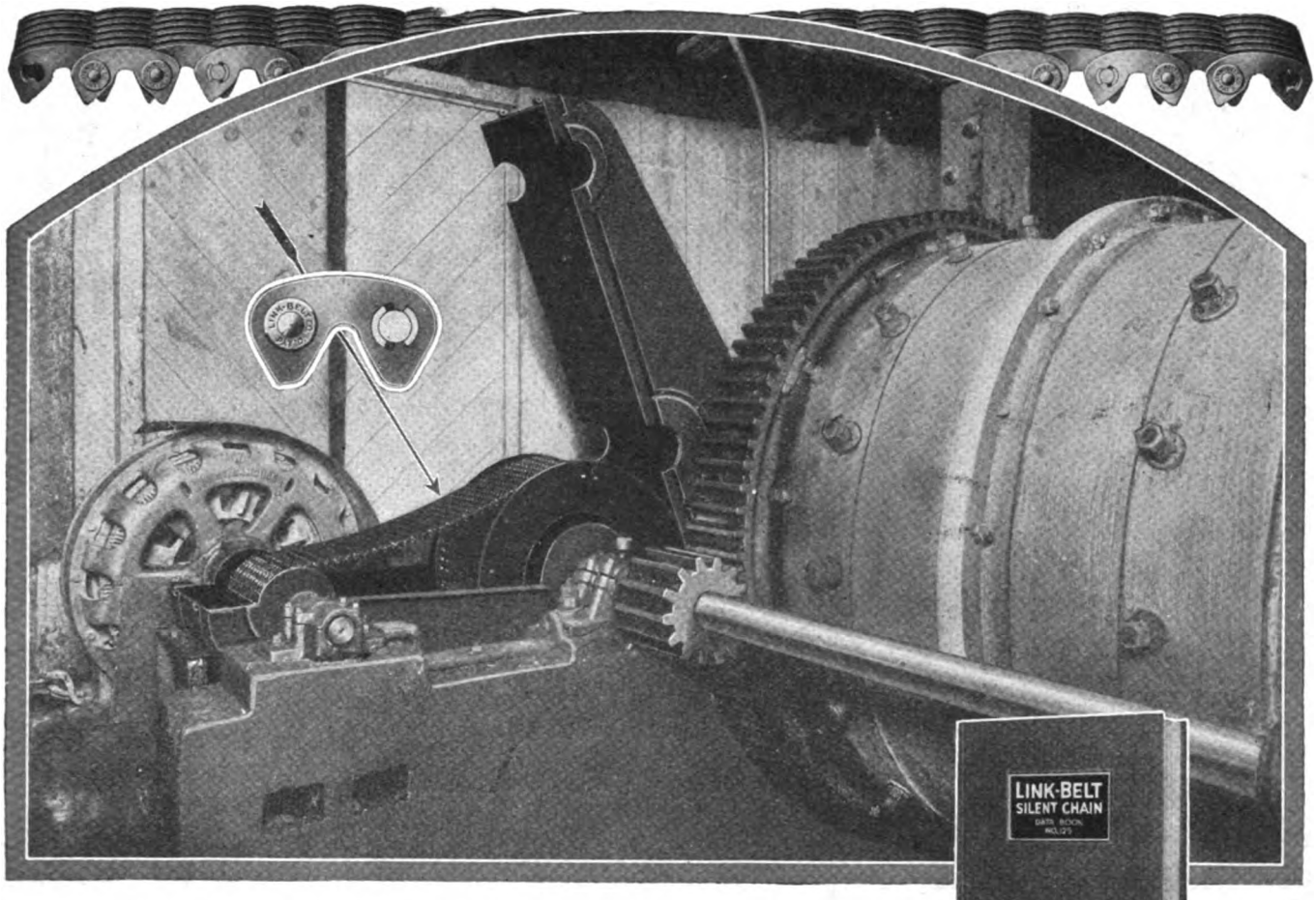
COWAN TRUCK CO., 12 WATER ST., HOLYOKE, MASS.

Representatives in Principal Cities

Largest Manufacturers of Complete Hand and Electric Industrial Truck Systems

2076-N

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Chain the Motor to Your Machine

TRANSMIT your power without slip. Place the motor to suit your convenience, on short centers, and enclose the silent chain drive in a Link-Belt dust-proof, oil-retaining "Safety-First" casing.

Then you will have an effective drive, one that will give long, dependable service.

Link-Belt Silent Chain is flexible as a belt—positive as a gear—more efficient than either—(98.2% efficient on actual test).

LINK-BELT COMPANY
810 S. MICHIGAN AVENUE CHICAGO
(OR NEAREST OFFICE LISTED BELOW)

Please send postpaid—Link-Belt Silent Chain Data Book No. 125.

Name _____
Firm _____
Street _____
Town _____
State _____
Industrial Engineer.

RETURN THIS COUPON

LINK-BELT COMPANY 1398

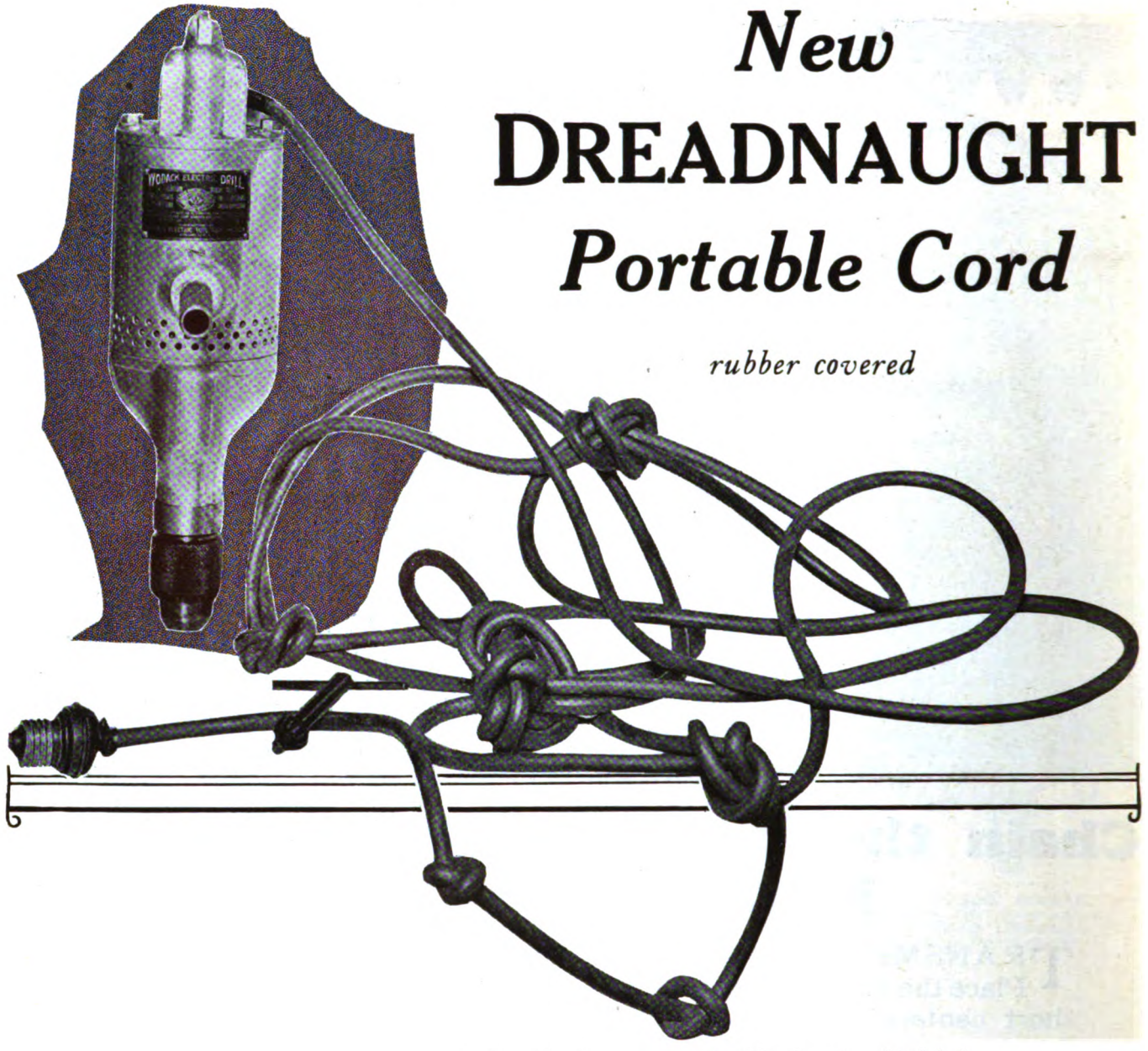
PHILADELPHIA, 2045 Hunting Park Ave. CHICAGO, 300 W. Pershing Road INDIANAPOLIS, 501 N. Holmes Ave.

New York 2676 Woolworth Bldg. | Buffalo 745 Ellicott Square | Kansas City, Mo. 307 Fimhurst Bldg. | Birmingham, Ala. 720 Brown-Marx Bldg.
Boston 49 Federal St. | Wilkes-Barre 826 Second Nat'l Bank Bldg. | Denver 520 Boston Bldg. | Charlotte, N. C.
Pittsburgh 335 Fifth Ave. | Huntington, W. Va., Robson-Prichard Bldg. | Atlanta 24 Marietta St. | J. S. Cothran, 909 Com'l Bank Bldg.
St. Louis 705 Olive St. | Cleveland 329 Rockefeller Bldg. | Louisville, Ky. 321 Starks Bldg. | Link-Belt Limited, Toronto and Montreal
Detroit 4222 Woodward Ave. | New Orleans 504 Carondelet Bldg.

H. W. CALDWELL & SON CO.:—Chicago, 1700 S. Western Ave. New York, 2676 Woolworth Bldg. Dallas, Texas, 709 Main St.
LINK-BELT MEESE & GOTTFRIED CO.:—San Francisco, 19th and Harrison Sts. Los Angeles, 400 E. Third St. Seattle, 820 First Ave., S. Portland, Ore., 67 Front St.

LINK-BELT
SILENT CHAIN DRIVES

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New DREADNAUGHT Portable Cord

rubber covered

This new **PARANITE** cord, like all other wires and cables bearing this label, is "more than code requires" in all the details of its manufacture.

More than this, Dreadnaught Portable cord is superior to the usual rubber covered portable cords now sold.

The rubber cover, thick, tough, practically everlasting even in the severest service, is of the same quality as the rubber in high grade tire treads.

This thick rubber cover is put on under enormous pressure over the double conductors, which are insulated with 30% rubber and braided with an indicating tracer. Pressure forces the soft, unvulcanized rubber tightly around the conductors. The pressure is maintained and after vulcanizing the result is a tough, dense wall of live rubber that withstands wear remarkably.

It's **PARANITE** quality and service all the way through.

Indiana Rubber & Insulated Wire Co.

Jonesboro, Indiana

810 Marquette Bldg., Chicago

The Thomas & Betts Co.

63 Vesey St., New York

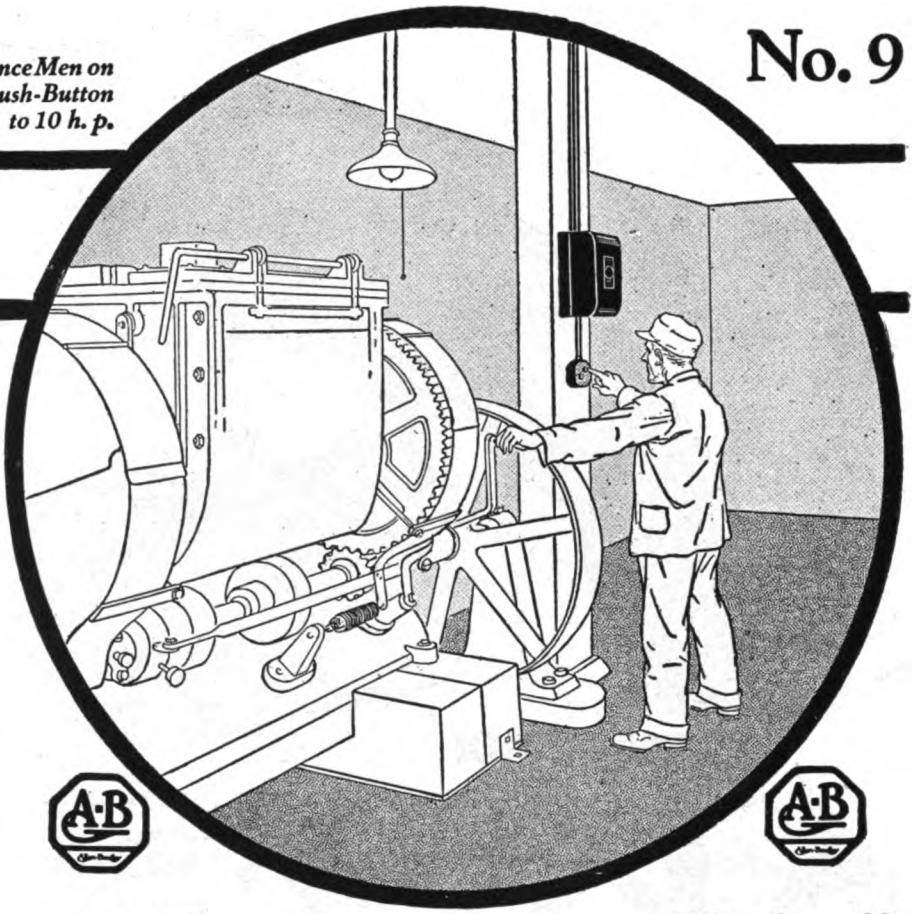
If it's* PARANITE *it's right

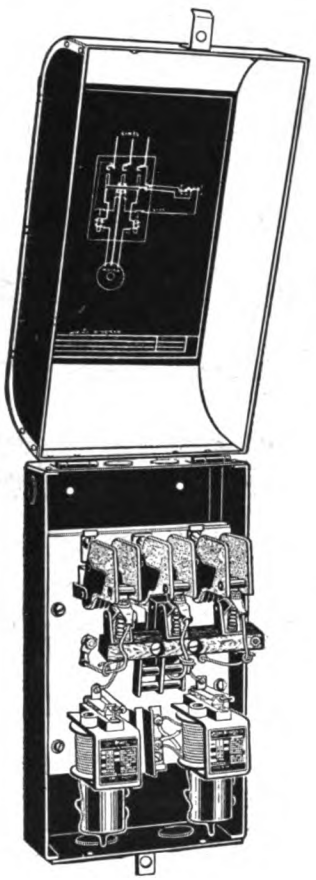
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One of a series of talks to Maintenance Men on the Allen-Bradly Type J-1552 Push-Button Starter for Induction Motors of 1 to 10 h. p.

No. 9

Safety





J-1552 Always means "Safety"

1st—To Men, because the touch of a button starts or stops the motor with no more risk to the workman than the pushing of an electric light button. The switch is enclosed and all "live" parts are not accessible to the shop hand. The motor cannot start accidentally after a shut-down.

2nd—To Motors, because the accurate time limit overload relays detect continued overloads and stop the motor before a burnout is possible.

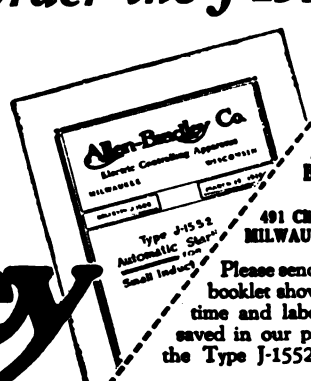
3rd—To Machines, because the motor cannot continue to operate with a heavy overload, as is often the case with over-fused starting switches. The relays automatically reset to the correct value after tripping.

Some Big Features

1—Arc shields and blow outs on ALL phases.
2—Inverse time element overload relays.
3—Copper-to-copper rolling contacts.
4—Roomy steel enclosing cabinet.
5—Knockouts for conduit wiring.

Play safe—always order the J-1552

Allen-Bradley Co.
Electric Controlling Apparatus
491 Clinton Street, Milwaukee, Wis.



ALLEN-BRADLEY CO.
491 Clinton Street
MILWAUKEE, WIS.

Please send me your booklet showing how time and labor can be saved in our plant with the Type J-1552 Switch.

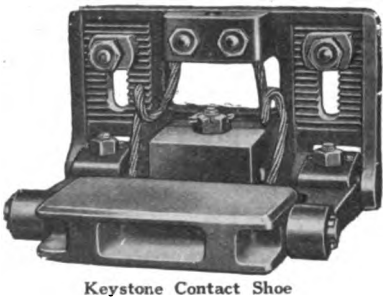
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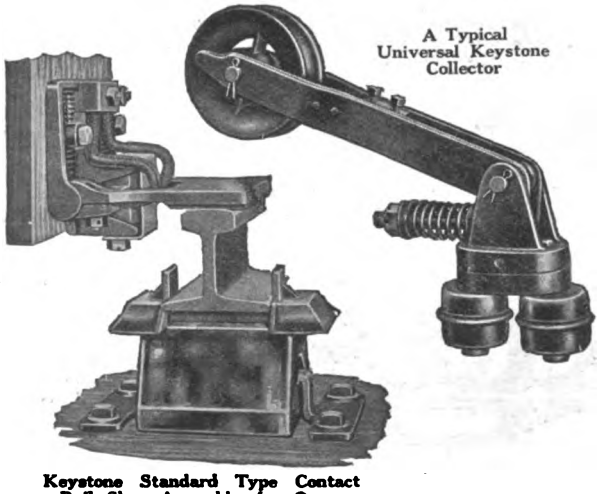
Allen-Bradley
TYPE J-1552
ACROSS-THE-LINE STARTING SWITCH

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Keystone Contact Shoe



A Typical Universal Keystone Collector

Keystone Standard Type Contact Rail Shoe Assembly for Over-Running Contact

Keystone Third Rail Equipment will permit the maintenance of reliable electrical contact at all times, indoors or out. It meets all industrial conditions as proved by an extensive list of diversified industries, representative of which are:

American Car & Foundry Co.; Baldwin Locomotive Works; Carnegie Steel Co.; General Motors Corp.; Hartford Electric Light Co.; Link Belt Co.; Philadelphia Rapid Transit Co.; Victor Talking Machine Co.; Youngstown Sheet & Tube Co. and many others.

For your third rail electrical system and carrier contact, specify reliable sturdy, proven Keystone Equipment.

Send for data sheets

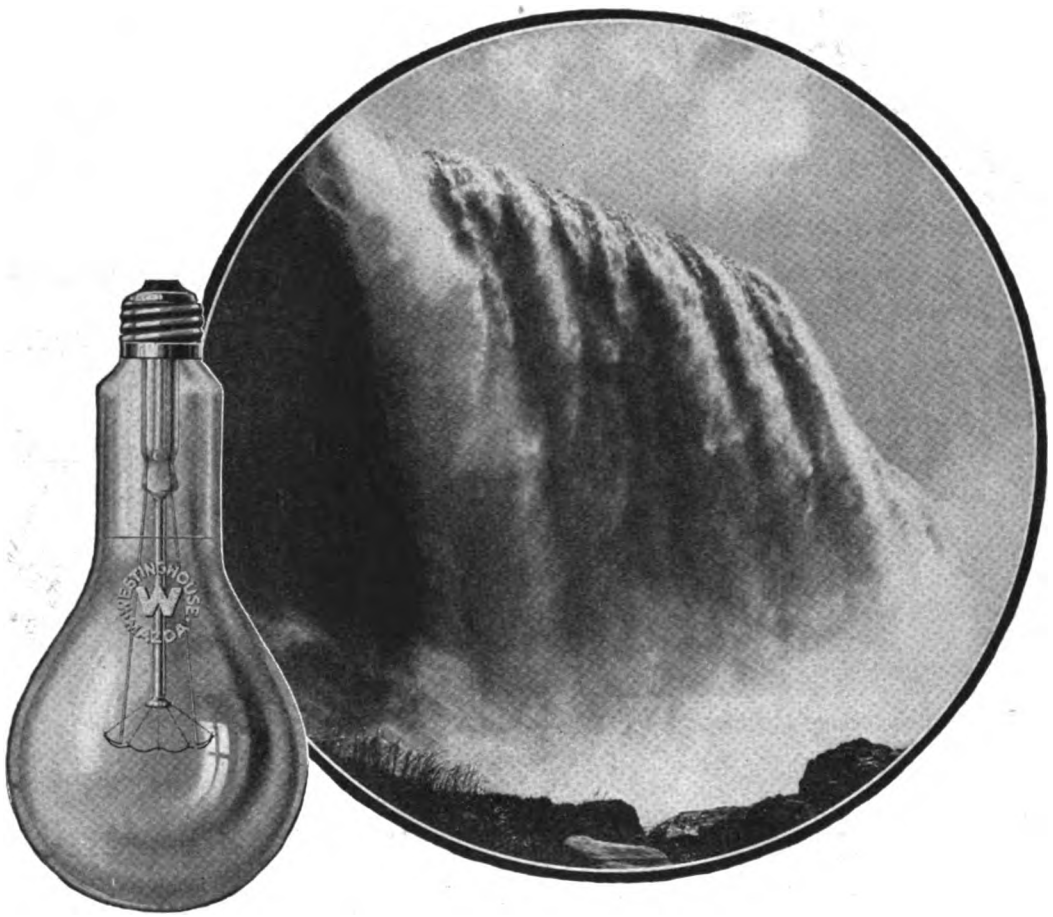
ELECTRIC SERVICE SUPPLIES CO.

Electric Railway and Mine Haulage Material

PHILADELPHIA 17th and Cambria Sts. | PITTSBURGH 829 Oliver Building | SCRANTON 316 N. Washington Ave.
NEW YORK 50 Church St. | CHICAGO Monadnock Bldg.

Canadian Agents
Lyman Tube & Supply Co., Montreal, Toronto, Winnipeg

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The Test of Quality Is Demand

The capacity of one of the largest hydro-electric power plants at Niagara Falls is over 227,000 kilowatts.

As huge an amount of power as this represents, it would not be sufficient to light the total number of Westinghouse Mazda C (gas-filled) Lamps manufactured in a period of thirty days.

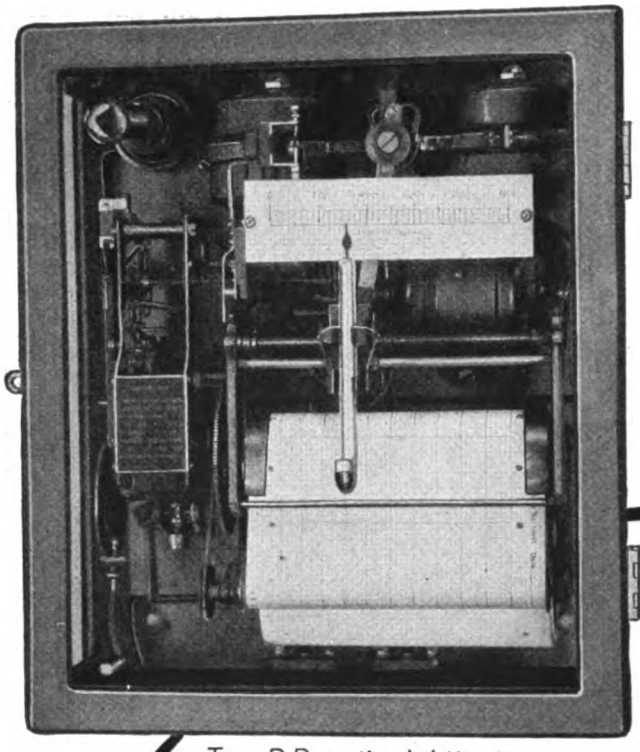
The demand for Westinghouse Mazda C Lamps has increased so tremendously that it has necessitated a constant expansion of manufacturing facilities.

This is due directly to the proven fact that the Mazda C Lamp, when used with the proper reflector, is the most efficient and economical lamp for the general lighting of factories, offices, and stores.

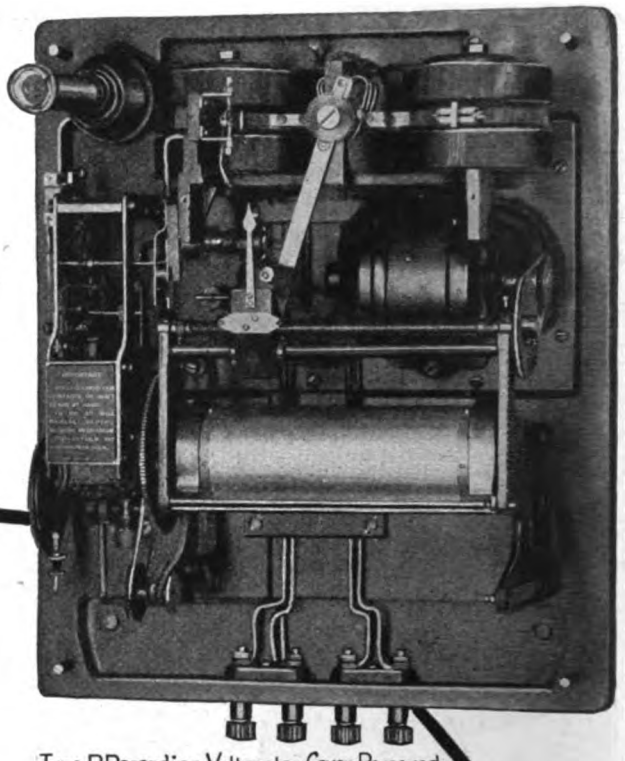
WESTINGHOUSE LAMP COMPANY
165 BROADWAY, NEW YORK, N. Y.
Sales Offices and Warehouses Throughout the Country
For Canada: CANADIAN WESTINGHOUSE CO., Ltd., Hamilton, Canada

Westinghouse

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Type R Recording Wattmeter



Type R Recording Voltmeter, Cover Removed

Westinghouse Recording Instruments

Portable—Switchboard—Wall Types

—have the following advantages:

Improved zero reset. Stronger calibrating spring. Improved pen carriage. Larger control motor. Improved re-roll mechanism. Large, accessible terminal studs.

All these instruments have indicating dials rendering the use of separate indicating instruments unnecessary, thereby making a distinct saving in certain installations.

Particularly adapted for recording and indicating the total power generated by central stations. Very useful for recording maximum demand; line voltage; station curves; arc circuits; electrolysis; motor tests; and electric traction investigations.

They are also very useful instruments for various engineering investigations and for recording the performance of cranes and hoists; printing presses; steel rolling mills; textile mills; paper mills; and other industrial plants.

Write for Leaflet 20049 which gives full particulars

Westinghouse Electric & Manufacturing Company
Newark Works, Newark, N. J.

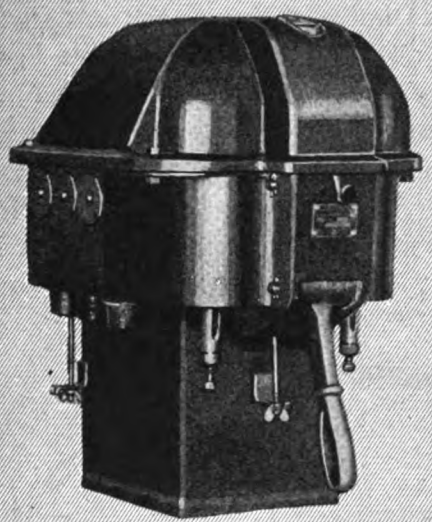
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse

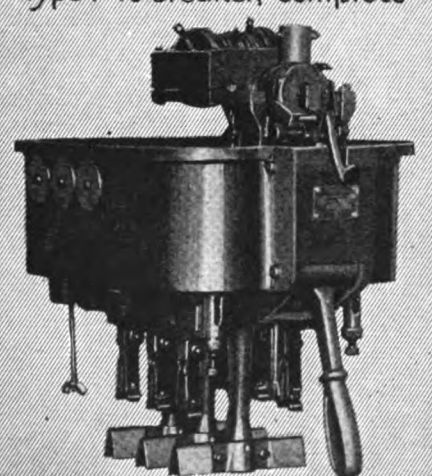
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A Westinghouse Oil Circuit Breaker, Type F-10, For Industrial Applications

Capacities up to 200 amperes, 2500 volts; 300 amperes, 750 volts. Indoor service, Automatic and Non-Automatic Direct Control, Wall, or any vertical-surface mounting.



Type F-10 Breaker, Complete



Type F-10 Breaker, Cover and Tank Removed.

The Type F-10 Oil Circuit Breaker is simple, reliable, inexpensive and sturdy in construction. It satisfactorily controls motor circuits and other low power-factor loads.

The illustration shows a Type F-10, 200 ampere, 2500-volt, 3 pole, single-throw breaker, equipped with full automatic, series-current trip overload coils inverse time limit, and under-voltage-release attachments, and voltage transformer.

Furnished also with electric lockout, and interlock device.

The Type F-10 Oil Breaker is fully described in Descriptive Leaflet 3400; ask for a copy.

Westinghouse Electric & Manufacturing Co.

East Pittsburgh, Pa.

Sales Offices in All Principal Cities of the United States and Foreign Countries

W WESTINGHOUSE ELECTRIC

A Drip-proof and Dust-proof Breaker for Industrial Application.

Westinghouse

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The Name and

When the name Westinghouse made its first appearance upon a piece of electrical apparatus it was conceived and placed there as a mark of the inherent integrity of the equipment. Our Founder set the highest ideals as his standard, laid his plans accordingly, and so built his organization that the slightest deviation from the original purpose would not be tolerated.

So, today, the circle "W" trade-mark upon a motor is the absolute guarantee that it is of the highest quality. Many years of engineering design and manufacturing experience are built into every Westinghouse motor. These motors have stood the test of time, the abuse of man and machinery, and have successfully met the most gruelling demands ever placed upon motor service.

Each industry naturally makes different demands upon a motor. To meet just such conditions, Westinghouse engineers made a thorough study of the requirements of each operating condition, and from this practice sprung the complete line of Westinghouse motors. Some are designed and made especially for particular work, such as textile and paper-machine motors. Others are made dust-proof and waterproof, each for its particular job. But no matter what the application, the underlying principle of all Westinghouse motors is the same. They are like the proverbial house that was founded upon a rock.

Is it any wonder that Westinghouse motors are doing duty in every corner of the earth to the complete satisfaction of their operators?

Should they not be doing duty in your plant?



The Westinghouse type CS motor—ready for active campaigning.

Westinghouse
Electric & Manufacturing
Company
East Pittsburgh, Pennsylvania
Sales Offices in
All Principal Cities of the
United States and
Foreign Countries

W
WESTINGHOUSE
ELECTRIC

Westinghouse

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The Trade-mark



A series of advertisements recently run, outlining Westinghouse developments in the electrification of diversified industries.



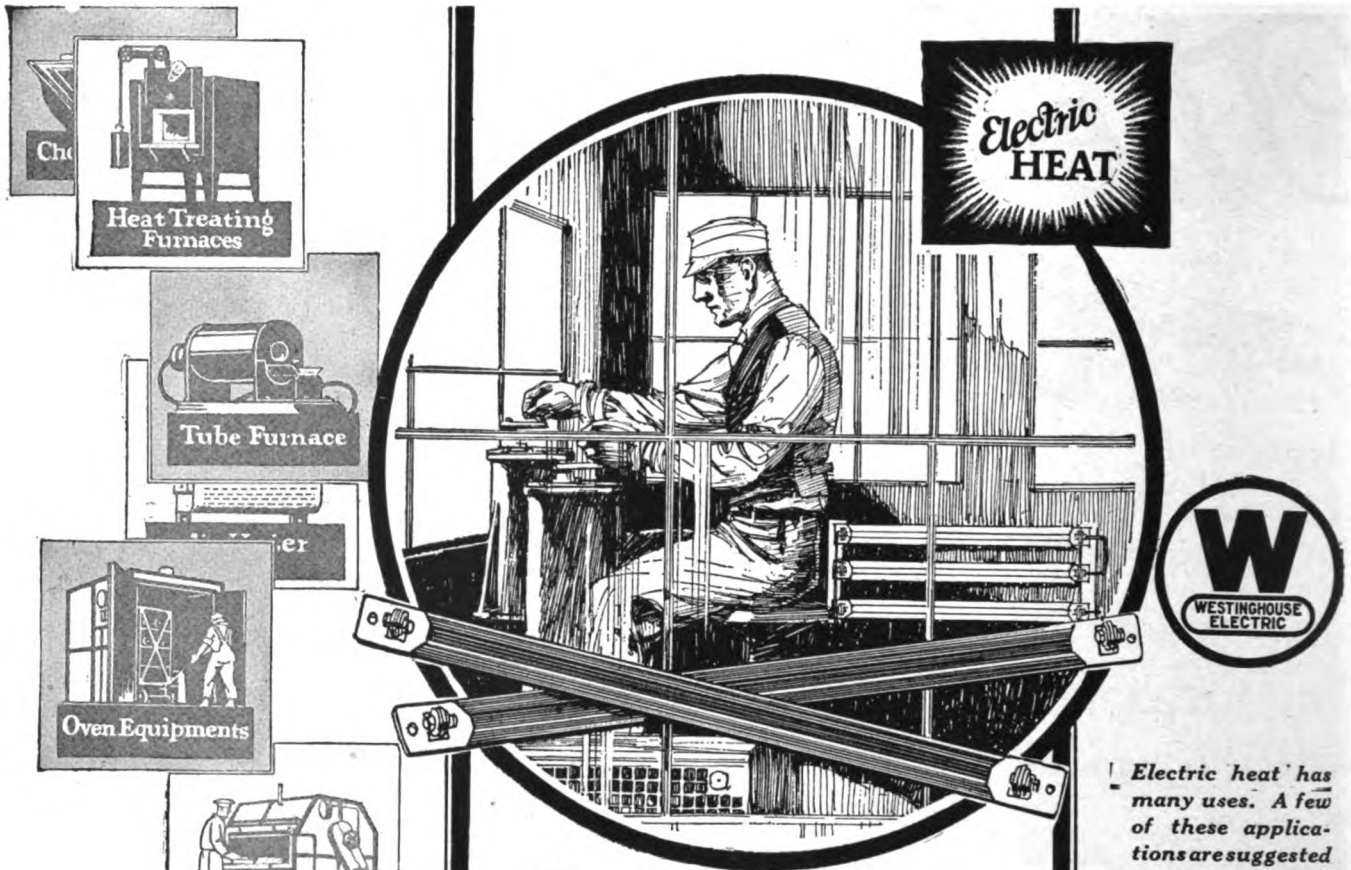


A part of a window display celebrating the fifty-second anniversary of a large Pittsburgh merchant. The motor has been retired from active duty, but there are many others built upon its experience.

The FIRST MOTOR — Built By — Westinghouse

Westinghouse

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Electric heat has many uses. A few of these applications are suggested by the small sketches. Electric heat can be used in your business.

Strips of *Electric* Heat

Right now is the time to install them; when Jack Frost is beginning to reach out with his cold fingers to nip some of those exposed pipes—when the watchman begins to visit the boiler room frequently because his shanty is so cold—when you begin to realize it is almost cruelty to ask a man to work all day in a cold crane cab.

Westinghouse electric space heaters save all this inconvenience. They are inexpensive, easy to install, and do not cost much to operate. Let your electrician wire up a couple of space heaters in some of those hard-to-heat places, and see how nicely they take the chill off on a cold morning. No fumes, no dirt, no flames to start a fire. Just turn on the heat when you need it, and turn it off when you are through.

A postal to the nearest Westinghouse office will bring sizes and prices. Better hurry, before cold weather sets in.

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

East Pittsburgh Pennsylvania

Sales Offices in All Principal Cities of the United States and Foreign Countries.

See Your Telephone Directory



Send for your copy today.

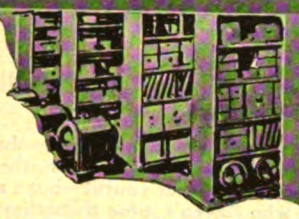


An occasional publication containing accounts of heating installations of interest to every executive. We shall be glad to put you on the mailing list. Write for a copy today.

Westinghouse

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MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES



In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that can be done and the dollar-savings that are possible depend on:
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.
Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.



OUR RECOMMENDATION IS YOUR PROTECTION

CARROLL
ELECTRIC COMPANY, Inc.
COMPLETE STOCK
WIRING SUPPLIES
MAZDA LAMPS
MOTORS
MACHINERY
EQUIPMENT

Prompt Shipment from Either

BALTIMORE, MD. 38 S. Calvert St.
WASHINGTON, D. C. 714 12th St., N. W.



Send for descriptive folder on "Little Giant" and "Big Buster"

PRACTICAL PULLING TOOLS
—that fill an every-day need

The "Little Giant" and the "Big Buster" cover a range of work which is not approached by any other combination of pulling tools on the market. These tools cannot spread, turn or slip off the work; no arm locks required.

"THE HARDER THE PULL—THE TIGHTER THE GRIP"

A principle quickly understood and appreciated by mechanics who have had experience with ordinary pullers.
"Little Giant" and "Big Buster" will easily and quickly pull commutators, wheels, pulleys, gears, pinions, bearings or anything with a tight fit or that is hard to get at with ordinary tools.
The "Little Giant" is the only Puller permitting adjustments of one or more arms to different lengths for uneven inside or outside pulls. This Tool has FOUR arms.

PREMIER ELECTRIC COMPANY
MANUFACTURERS—EST. 1905
3804 RAVENSWOOD AVENUE CHICAGO

Send To-day for the "Electrical Worker's Friend"

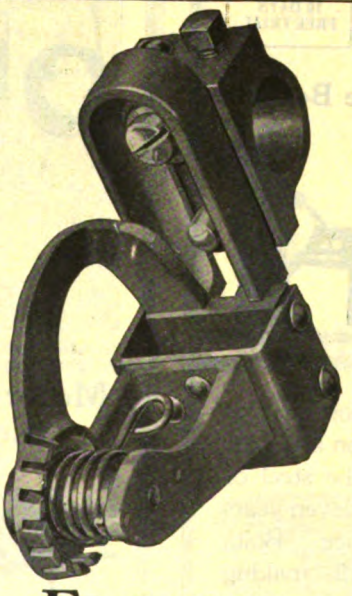
An electrical book of 66 motor drawings with complete instructions for rewinding and reconnecting A. C. motors. Special at..... $3.00=

Or write for full particulars of this valuable book

SMITH & SMITH PUBLISHING CO.
Dept. D, 7428 Hermitage St. Pittsburgh, Pa.

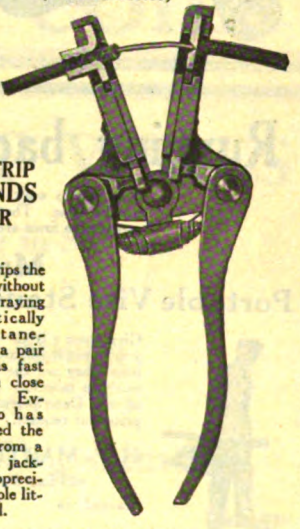
precision

PRECISION, simplicity of construction, durability.
And quick delivery.
These are the factors responsible for the wide adoption of FLOWER Brush Holders.
Our illustrated bulletin showing many models will be mailed you upon request.



FLOWER brush holders
D. B. FLOWER, 1217 Spring Garden Street, Philadelphia
Manufacturer of Brush Holders for Motors, Rotary Converters, Generators and Dynamos.

BARD-PARKER
WIRE INSULATION STRIPPER
(Wood Patent)



WILL STRIP 1200 ENDS AN HOUR

Cuts and strips the insulation without nicking or fraying—automatically and instantaneously—like a pair of pliers, as fast as you can close your hand. Everyone who has ever whittled the insulation from a wire with a jackknife will appreciate this simple little hand tool.

$5.00 f.o.b. New York
Ask your dealer or write us direct.
Bard-Parker Company, Inc.
150 Lafayette St. New York, N. Y.

TINOL
Solder in Paste Form
contains no form of acid or harmful salts. Best and safest solder to use for all delicate soldering operations. Endorsed by the largest electrical manufacturers in the country.

Write for sample and prices.

American Solder & Flux Co.
16th St., below Indiana Ave. Phila., Pa.



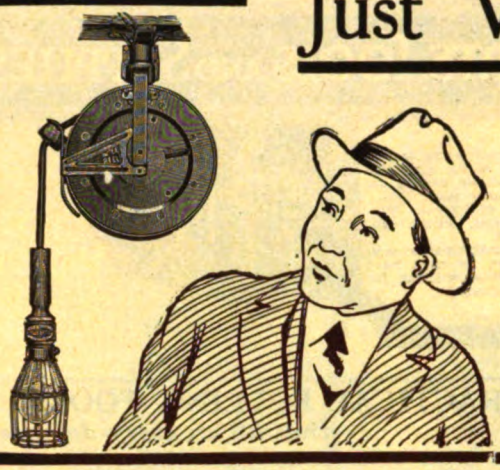
NO Spark Carbon Brushes
are Self Lubricating. They last longer and serve better than ordinary brushes. Give them just one trial.
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FOR ELECTRIC LAMPS
Also extensively used for electric drills and other small electrical unit extensions.

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SAFETY TOOLS
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10 DAYS FREE TRIAL

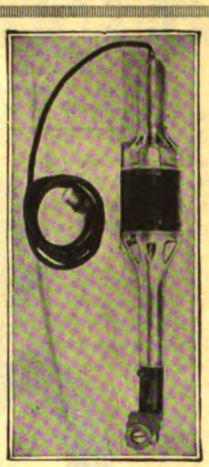
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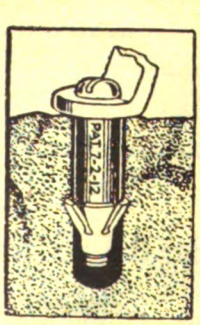
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Save Time, Money and Material in turning, repairing, undercutting and cleaning Commutators, and Collector Rings. Write us and we will tell you how to try it out at our expense.

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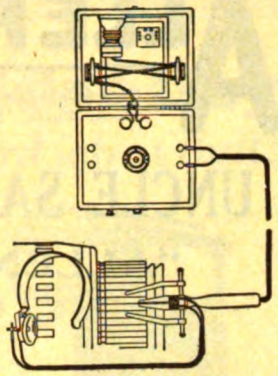
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Manufacturers of Armature and Field Coil Testing Apparatus.

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$26.00 SET FOR $12.00

(SUBJECT TO PRIOR SALE)

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Leather Case Aluminum Frame

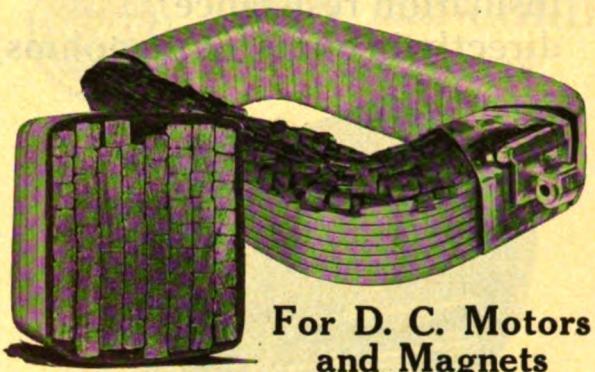


For testing line circuits for shorts, leaks and opens, testing armature coils, field coils and transformer coils or any tests made with generator and buzzer. Made to Government specifications.

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For D. C. Motors and Magnets

Advantages of Aluminum Field Coils—

Permanent insulation.
No baking or charring of insulation.
Uniform distribution of heat.
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Moisture and heat resisting.
50% to 60% weight reduction.
Brass spools not needed on large coils.
Less chafing due to lighter weight.
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Longer life—less renewals.

Lind Aluminum field Coils have been in use in Europe for the past fifteen years. Since they have been manufactured in America they have been successfully used by more than 60 different companies, and many repeat orders have been placed.

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Made by the makers of "DETROIT" Belt Lacing and Closing Machines

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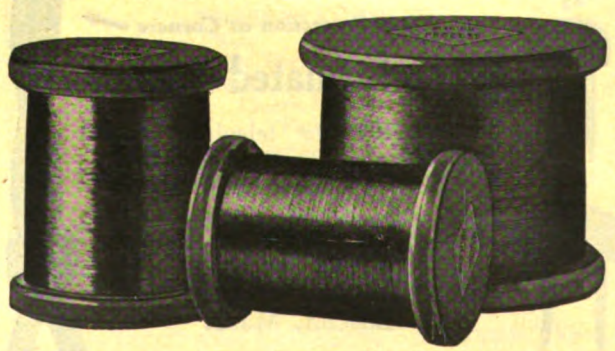
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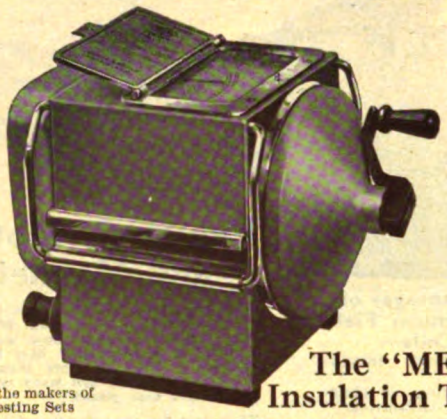
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The "MEG" Insulation Tester

"Just the thing" for trouble-shooting, acceptance tests and tests after repairs on generators, motors, short-length cables, switchboards, wiring installations and transformers where 100 megohms is "high enough."

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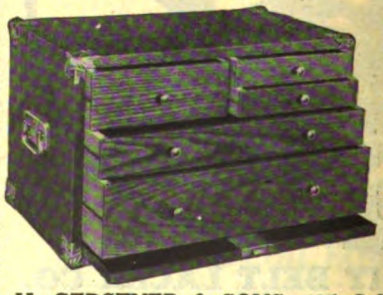
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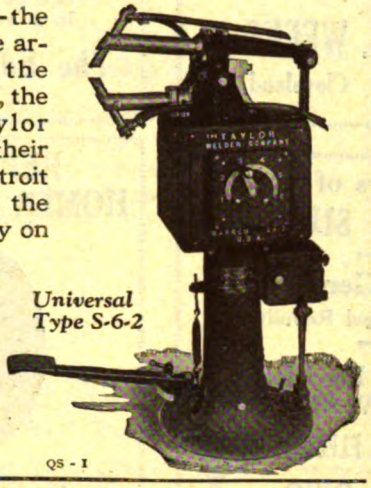
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But it doesn't matter—the more cumbersome the article is to handle and the more difficult the work, the more emphatically Taylor Spot Welders prove their superiority. One Detroit manufacturer makes the above record regularly on one machine!

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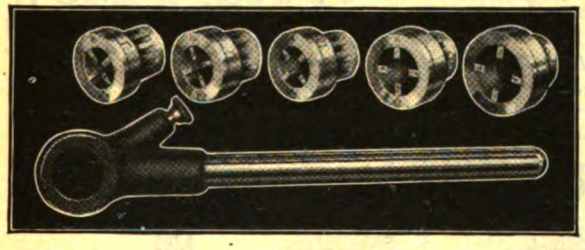
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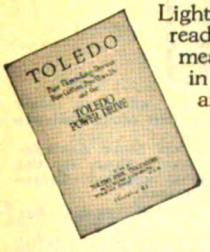
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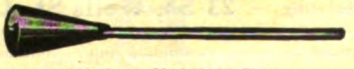
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in the pitting of commutators, will prevent a break down of the motor or generator. The machine can be set running again in a few minutes.

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if it's insulating material,
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QUICK—EASY—ACCURATE



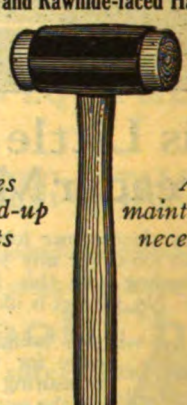
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Mallets and Rawhide-faced Hammers



Saves battered-up parts

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Will transmit an effective blow without damage to the most delicate surface.

But the blow is not more destructive to the tool itself than to the object to which it is applied—therefore, doubly economical.

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Large factory—150 skilled workers—28 years' experience. Heavy difficult work our specialty. Electrical Engineers and Road Men.

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HIGH SPEED

Undercut	Corliss R-11
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These applications represent standard generators under normal operating conditions. There are several additional grades to cover all general and special requirements.

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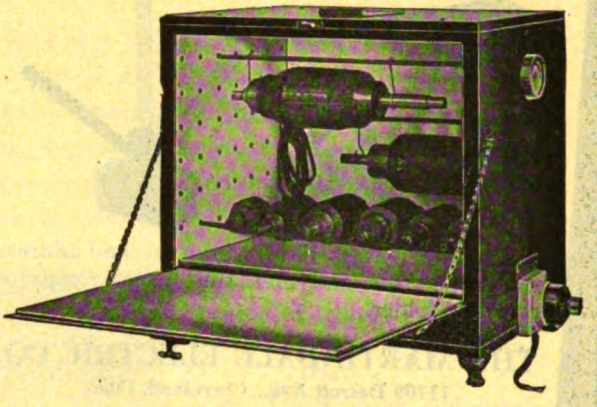
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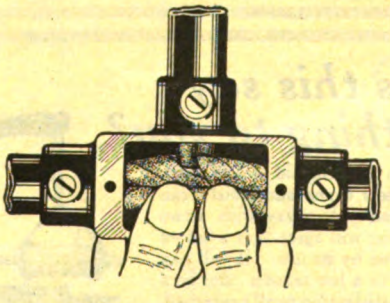
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TAPLET
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By saving two and three minutes on every installation you put money in your pocket. This roominess is an exclusive feature in TAPLETS.



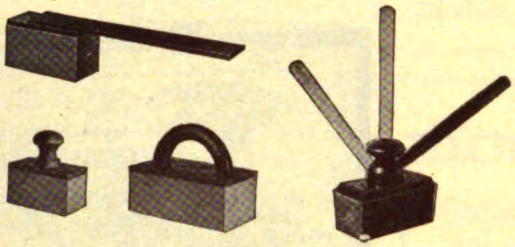
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The handiest and most practical blower for blowing dust and dirt out of armatures, field coils, switchboards, machinery, line shafting, stock bins, shelves, etc.
Lowers fire risks. Makes more healthful working conditions. Reduces depreciaton in electrical and other machinery.
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The CADILLAC BLOWER has proven its worth and is performing successfully with hundreds of uses in shoe factories, cotton mills, grain elevators, coal mines, engravers, printers, wood working plants, textile mills, box factories, and every line of industry.
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Manufacturers of the Cadillac Electric Vacuum Cleaner
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Order Them from Stock

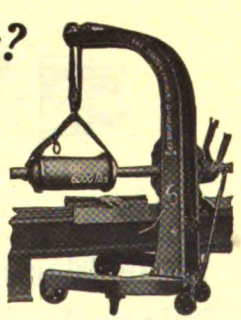
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USE LE CARBONE CARBON BRUSHES

They talk for themselves

COST MORE PER BRUSH
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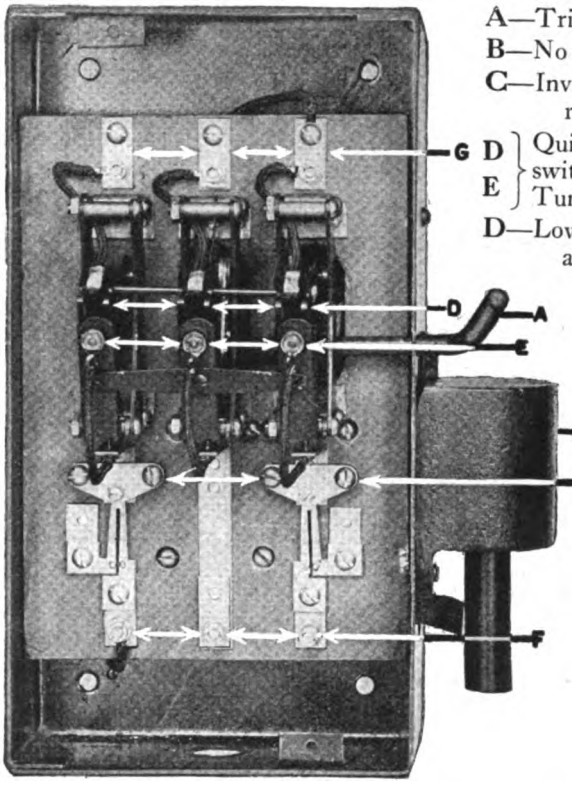
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Use Minibreakers

The smallest, most economical across-the-line starter for Alternating Current Motors up to 1 H.P., 110 volts, single phase; 5 H.P., 220-440 and 550 volts, two and three phase.

Minibreakers give both at starting and running complete protection, are full automatic (trip free from the handle), have inverse time element overload protection, no voltage release and are arranged for emergency trip from remote points.



The use of Minibreakers eliminates the blowing of fuses, increases production and insures continuity of service.

A well protected motor is a credit to the electrical department and a satisfaction to the management.

Minibreakers offer the best possible protection obtainable at the lowest cost.

We also Manufacture:

Minibreakers for direct current across-the-line motor starting up to 1 H.P. 110 volts and 220 volts, and as motor protective devices only up to 2 H.P., 110 volts and 5 H.P., 220 volts.

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220 volts with no voltage release and emergency trip.

Dimensions—

6¼x13⅜x5½, with fuses.
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List price $22.50.

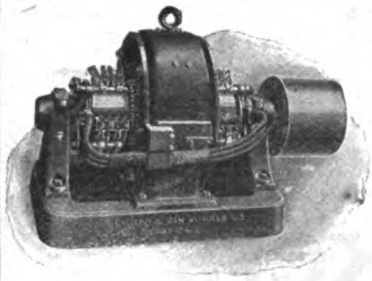
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Miniature Breaker Company, Inc.

203-14th St., Long Island City, N. Y.

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Allan Manufacturing & Welding Co., Inc.
Buffalo, N. Y., U. S. A.

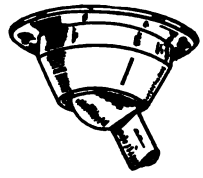
SPECIAL TRANSFORMERS

For Every Purpose

in your development work—in your laboratory—in any factory work requiring transformers—we stand ready to assist you in the design and in the custom-making of the exactly right transformer for you.

Send us your specifications

American Transformer Company
178 Emmet St., Newark, N. J.



QUAD QUALITY

SWIVEL HANGER

Catalog No. 451
Semi-Swing 45°
List Price 45c

Fits a 4-inch outlet box and will hang vertically even though box is tilted 45 degrees.

Especially suitable for open conduit work under sloping or saw tooth roofs.

QUADRANGLE MFG. CO.
553 W. Monroe St.
CHICAGO

Only Reliable Products Can Be Continuously Advertised

ELWELL-PARKER
6000 POUND
ELECTRIC LIFT TRUCK

Will pick up and deliver more materials day after day at less cost than any similar truck.



Request details as to this new Special, illustrated in Bulletin A535

The **Elwell-Parker Electric Company**
CLEVELAND



Browning Equipment is Appreciated the Minute It Is Used

BROWNING LOOP AND FIELD WINDER

Produces loops 25% faster than otherwise possible. A ruggedly built machine with two power shafts, three speeds on each. Embodies perfect control with instant start and positive stop. Winding head eliminates all waste ends.

BROWNING COIL SPREADER

Skilled operators spread 120 coils per hour, with ease, and secure most perfectly shaped coils possible to make. Coil holders and knuckle holders exert positive grips. Special "kick-up" attachment on knuckle. Browning Equipment, the Armature Winder's friend.

Over 100% Annual Return on Your Investment Assured
Let Us Give You Further Details

MANUFACTURED BY

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Triumph increases facilities for big motor production

HERE is unusual evidence of Triumph's newly expanded facilities for building heavy duty motors in sizes from 50 to 200 h. p.

Sixteen 75 h. p. slip ring motors like the four above have just been built by Triumph for one of the largest paper mills in the world, The Champion Coated Paper Company, for application to sixteen giant pulp beaters in their mill at Hamilton, Ohio.

With these Triumph motors, this mill is converting its battery of pulp beaters from steam to automatic motor drive and push-button control, with obvious savings and increased efficiency.

Triumph's capable staff of designing engineers, skilled factory personnel, and modern shop equipment are at your service in the production of motors of varied types in all sizes from 1 to 200 h. p.

Experienced Triumph application engineers are conveniently located in the larger cities, ready to bring to your conference table Triumph co-operation in solving the motor problems that arise in powering your plant for maximum efficiency.



This picture of the main production floor of the Triumph factory suggests the preparedness of the Triumph organization to efficiently and economically meet your motor requirements.

THE TRIUMPH ELECTRIC COMPANY

CINCINNATI, OHIO

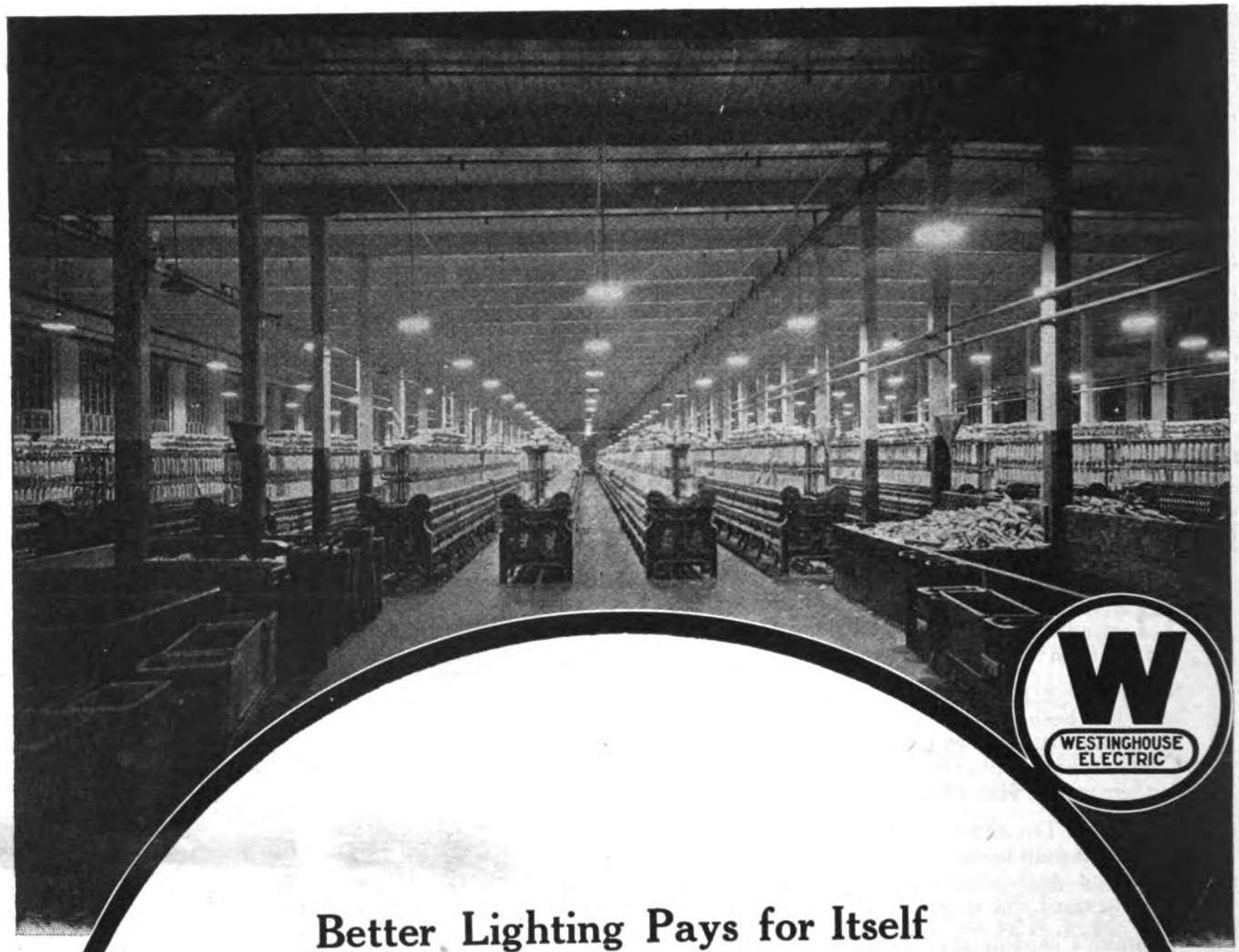
OFFICES IN PRINCIPAL CITIES

A. C. MOTORS—Squirrel Cage, Slip Ring, and "TR" Self Start Types
D. C. MOTORS—Type "F" Steel Frame and Constant Speed and Adjustable Speed Types

TRIUMPH

POWER-SAVING HEAVY-DUTY MOTORS

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W
WESTINGHOUSE ELECTRIC

Better Lighting Pays for Itself

Good lighting not only saves maintenance money, but it also helps you obtain higher earnings for your investment because it produces definite and measurable increase in production. The average results, computed from records made in hundreds of plants where the lighting conditions have been improved, show production increases of 12 per cent. In addition, spoilage was decreased 23 per cent and accidents decreased 25 per cent.

The investment required to produce these and many other benefits is so slight that in practically all cases it is the lowest part of the overhead charge. The manufacturer who tries to cut the cost of this lowest item saves but a few dollars at the most, and he does so at the expense of the two largest cost items on the list—labor and material.

Westinghouse Electric & Manufacturing Co.

George Cutter Works, South Bend, Indiana

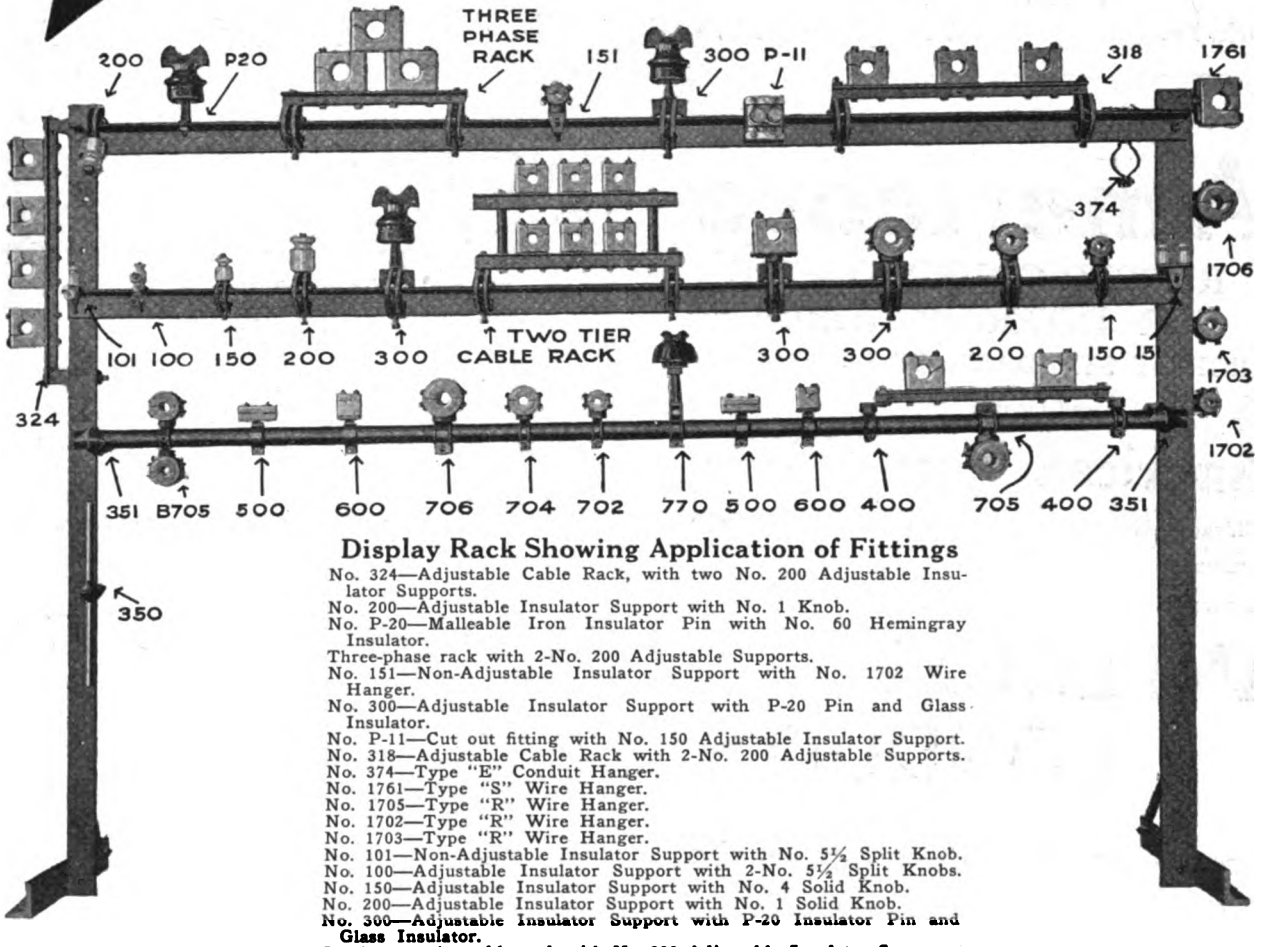
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse

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Wayman ELECTRICAL FITTINGS

Stronger Fittings with Longer Life and Lower Costs



Display Rack Showing Application of Fittings

No. 324—Adjustable Cable Rack, with two No. 200 Adjustable Insulator Supports.
No. 200—Adjustable Insulator Support with No. 1 Knob.
No. P-20—Malleable Iron Insulator Pin with No. 60 Hemingray Insulator.
Three-phase rack with 2-No. 200 Adjustable Supports.
No. 151—Non-Adjustable Insulator Support with No. 1702 Wire Hanger.
No. 300—Adjustable Insulator Support with P-20 Pin and Glass Insulator.
No. P-11—Cut out fitting with No. 150 Adjustable Insulator Support.
No. 318—Adjustable Cable Rack with 2-No. 200 Adjustable Supports.
No. 374—Type "E" Conduit Hanger.
No. 1761—Type "S" Wire Hanger.
No. 1705—Type "R" Wire Hanger.
No. 1702—Type "R" Wire Hanger.
No. 1703—Type "R" Wire Hanger.
No. 101—Non-Adjustable Insulator Support with No. 5½ Split Knob.
No. 100—Adjustable Insulator Support with 2-No. 5½ Split Knobs.
No. 150—Adjustable Insulator Support with No. 4 Solid Knob.
No. 200—Adjustable Insulator Support with No. 1 Solid Knob.
No. 300—Adjustable Insulator Support with P-20 Insulator Pin and Glass Insulator.
Special two tier cable rack with No. 200 Adjustable Insulator Supports.
No. 300—Adjustable Insulator Support with No. 1761 Type "S" Wire Hanger.
No. 300—Adjustable Insulator Support with No. 1705 Type "R" Wire Hanger.
No. 200—Adjustable Insulator Support with No. 1704 Type "R" Wire Hanger.
No. 150—Adjustable Insulator Support with No. 1702 Type "R" Wire Hanger.
No. 151—Non-Adjustable Insulator Support with P-15-2 Cleat Fitting.
No. 351—Type "C" Conduit Hanger.
No. B-705—Two wire bus fitting.
No. 500—Two wire cleat fitting for 1¼" pipe.
No. 600—Single wire cleat fitting for 1¼" pipe.
No. 706—Type "R" Bus Support.
No. 704—Type "R" Bus Support.
No. 702—Type "R" Bus Support.
No. 770—Type "H" Support with P-20 Insulator Pin.
No. 500—2 wire cleat fitting for 1¼" pipe.
No. 600—Single wire cleat fitting for 1¼" pipe.
No. 400—Cable Rack attachment for 1¼" pipe.
No. 705—Type "R" Bus Support.
No. 351—Type "C" Conduit Hanger.
No. 350—Type "C" Conduit Hanger.

A new Folder just off the press describes these fittings in detail—write for a copy—it's free.

Wayman Electric & Mfg. Co.
East Palestine
Ohio

LEADERS—EVERY ONE OF THEM ALL LABOR SAVING DEVICES

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SALAMANDER WIRES and CABLES

The highly desirable finish on Salamander wires and cables is only obtained by using long asbestos fibres. These fibres do not require a cotton thread as a carrier during the insulating process, thereby avoiding the tendency of opening.

The resulting Salamander insulation gives a smooth, hard continuous wall.

YORK INSULATED WIRE WORKS
of General Electric Co.
York, Pa. 1737 Broadway, N. Y. C.

BARE AND INSULATED WIRES

WEATHER-PROOF "O.K." LINE AND HOUSE WIRES

"OK" Weatherproof Wire
"Parac" Rubber Wire
Slow Burning Wire
Bare Copper Wire

PHILLIPS WIRE COMPANY
Pawtucket, R. I.

Americore

RUBBER COVERED WIRE
FOR INTERIOR WIRING
HIGHEST STANDARD OF EXCELLENCE
Send for descriptive book

American Steel & Wire Company
Chicago—New York

WIRES and CABLES For PLANT WIRING

Rubber, Cambric & Paper Insulations
All Sizes *All Services*
We Have a Distributor Near You—

Safety Insulated Wire & Cable Co.
114 Liberty Street New York
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INTERIOR CONDUITS

American Circular Loom Co.

AMERICAN CIRCULAR LOOM CO. TRADE MARK

90 West Street
New York
Boston Los Angeles Seattle
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Get that wire—*when* you want it!

For your repair work you want your orders filled promptly. We carry complete stocks of round magnet wire all insulations sizes No. 8 and finer. Call on us when you need wire quickly.

American Enameled Magnet Wire Co.
Muskegon, Mich.

DUDLO QUALITY DIDN'T JUST HAPPEN

but is the result of years of painstaking effort towards improvement. Specialization plus large and continuous production are responsible for the reasonable cost of Dudlo wire and coils.

Write today for samples and quotations

Dudlo Manufacturing Co., Ft. Wayne, Indiana
Western Representative: A. S. Lindstrom, 111 New Montgomery St., San Francisco, Calif.

DUDLO

Magnet Wire and Windings

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An Offer to Maintenance Men

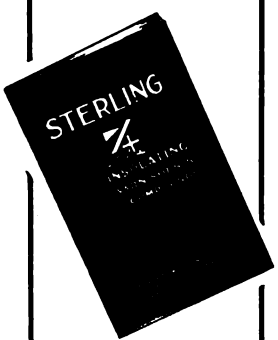
The men responsible for proper maintenance are the best judges of insulations.

But frequently, to secure advantageous prices, they are asked to order large quantities of insulations on the strength of some factory tests.

Service test is the one that counts, and to enable you to see for yourself the advantage of any Sterling product ,you can secure it in small quantities for test, and at small cost.

FREE

A book you need every day



Catalog D is an invaluable aid to the man concerned with motor maintenances. It contains specific data for your use in coping with insulation problems. Send for it.

Try a test of one Sterling insulation, to see the advantages—here is one you use regularly:

STERLING BLACK ARMATURE LACQUER (a slow air drying varnish, or rapid baking one which retains its flexibility much longer than ordinary air drying ones). We want you to try this lacquer.

It will show you a new service in a lacquer you use nearly every day—so we'll send you an introductory gallon for $1.35—or 5-gallon can at $1.25 per gallon—you to be the judge.

Get this Book Anyway

It is seldom that you have access to as complete a coverage of insulation problems.

We will gladly mail the handbook free to anyone who is interested in advanced insulation practice. When writing, mention any problems you may have—we'll be glad to help.

STERLING VARNISH

THE STERLING VARNISH COMPANY, PITTSBURGH, PA.

COTTON - ENAMEL - SILK - MAGNET WIRE — TRADE A1 MARK

A-1 MAGNET WIRE

Plain Enamel, Single Cotton Enamel, Single and Double Cotton Covered.

"AMERICAN BRAND"

Weather-proof Copper Wire and Cables
Slow Burning (Und.)
Weather-proof Iron Wire
Slow Burning Weather-proof Copper Wire and Cables
Bare Copper Wire and Cables

Are representative of the highest principles in manufacturing and merchandising in the wire industry.

American Insulated Wire & Cable Co.
Chicago, Illinois



MICANITE REGISTERED

INSULATION

For MOTORS, GENERATORS, *and* OTHER ELECTRICAL EQUIPMENT

Micanite Plate supplied for your own moulding or stamping or made to your specifications as tubes, rods, rings, flanges, spools, bushings, washers, sleeves, and as commutator segments in every size, shape, and thickness. Empire Oiled Materials in sheets, tapes, and tubes for a variety of electrical insulations.

Forty page catalog replete with photographs and data on all our insulation products sent promptly on request.

MICA INSULATOR CO.

Works: Schenectady, N. Y.
New York Office: 68 Church Street
Chicago Office: 542 So. Dearborn Street

Cleveland Agent: G. A. Morrell. Cincinnati Agent: Monroe Brass and Wire Co. San Francisco and Los Angeles Agent: Electrical Specialty Co.

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Founded 1878

OKONITE
TRADE MARK

Incorporated 1884

The Standard for Rubber Insulation

OKONITE PRODUCTS

are available for all electrical purposes.

They have stood the test of time and are recommended by prominent Electrical Engineers everywhere.

- Power Cables (Okonite and Varnished Cambric)
- Submarine Cables
- Parkway Wires & Cables
- Signal Wires
- Car Wires
- Jumper Cables
- Plough Leads
- Locomotive Headlight Wire
- Telephone and Telegraph Potheads
- Telephone & Telegraph Wires
- Okocord (hard service cords)
- Portable Cords
- Ignition Wires
- Okonite Splicing Materials
- Okoloom (Hard Finish for Hard Service)

Write for handbook
"INSULATED WIRE & CABLE"

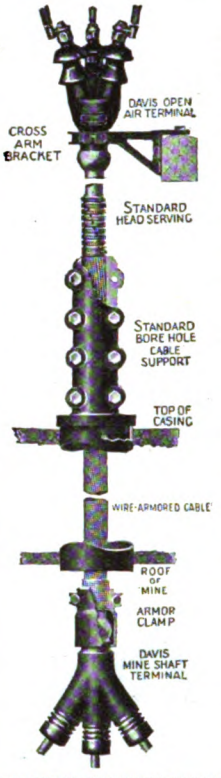
THE OKONITE CO., Passaic, N. J.

Sales Offices
NEW YORK ATLANTA SAN FRANCISCO

Agents
Central Electric Co., Chicago, Ill. The F. D. Lawrence Electric Co., Cincinnati, Ohio
Pettingell-Andrews Co., Boston, Mass. Novelty Electric Co., Philadelphia, Pa.

STANDARD

Wires, Cables and Cable Accessories



make for efficiency and dependability in the installation and operation of electric transmission systems.

The illustration shows how one or more electric cables can be safely and easily installed in the borehole of a mine or tunnel, or in any vertical position, by using STANDARD Borehole Cables with Cable Supports and Indoor and Outdoor Cable Terminals. A separate support is required for each cable.

For further imformation ask for Bulletin 700.

Standard Underground Cable Co.

Boston Washington Detroit
New York Pittsburgh St. Louis
Philadelphia Chicago San Francisco

The Best by Line Test

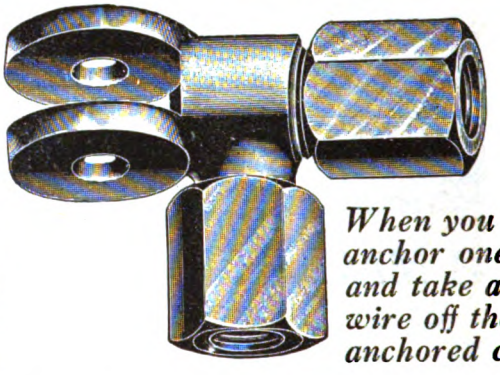
THOMAS QUALITY RELIABILITY

An American Standard Since 1873

Thomas Quality Insulators and Transmission Line Fittings

The R. Thomas and Sons Co.
East Liverpool. Ohio.
U. S. A.

SALES OFFICES
New York - Boston - Chicago - London
Western Electric Co. Inc. on Pacific Coast
Northern Electric Co. Ltd. in Canada



When you want to anchor one cable and take a branch wire off the anchored cable

DOSSERT CABLE ANCHOR

Consists of an elbow and clevis for the strain insulator—so arranged that pull is exerted on one cable only.

There are several types of Dossert Cable Anchors shown in the 15th Year Book, which catalogs the whole line.

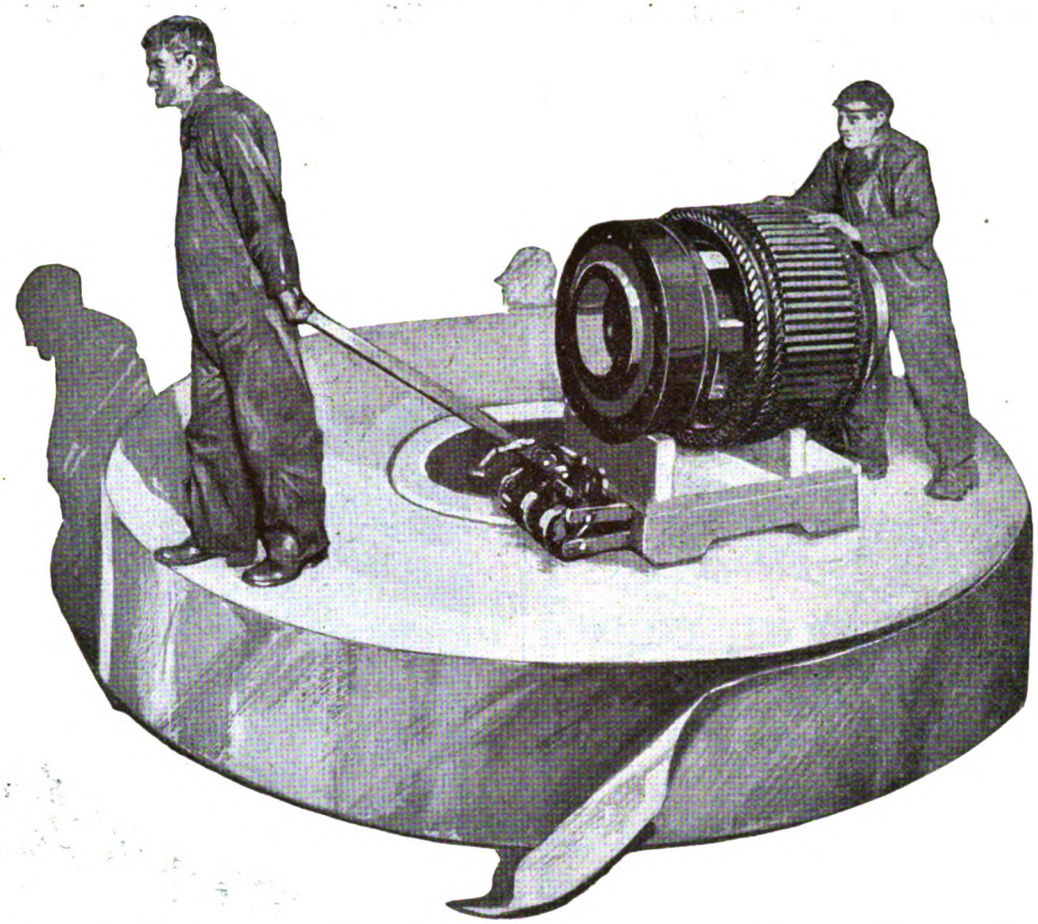
GET THIS BOOK



FREE

Dossert & Co.
242 West 41st Street
New York, N. Y.

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Putting Insulation Requirements on a Firm Foundation

It is not enough for a motor manufacturer or an industrial plant to standardize on one kind of varnished insulation simply because he buys it from the largest manufacturer of that product such as "Irvington."

It is not enough that today the majority of high tension insulated wires and cables in the United States are protected by Irvington Black Varnished Cambric.

But when we say that in comparison with other insulation, Irvington Black Varnished Cambric has 30% higher dielectric strength; 100% better heat resistance; 100% more alkali and acid resistance; 200% better aging qualities; 200% more resistance to oil than yellow varnished cambric, no further explanation of the foregoing facts is necessary.

Like many other manufacturers, you can build on a firm foundation, by standardizing on Irvington Black Varnished Cambric Tape.

IRVINGTON VARNISH & INSULATOR CO.
Irvington, New Jersey.
Established 1905

Sales Representatives:

Mitchell-Rand Mfg. Co., New York
T. C. White Electrical Supply Co., St. Louis
E. M. Wolcott, Rochester
F. G. Scofield, Toronto
L. L. Fleig & Co., Chicago
Consumers Rubber Co., Cleveland
Clapp & Lamoree, Los Angeles
aed San Francisco

Seven factors of Quality

High Dielectric Strength
High Resistance
Flexibility
Non Hygroscopic
Heat Resisting
Chemically Neutral
Maximum Elasticity

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Selwa

Selwa is the large hole in the ground that the Kaffir digs as a storehouse for his grain, etc. The entrance is covered with grasses so that raiders will have a hard time finding the hiding place.

Our artist has deftly depicted an unthinking person, just above such a storehouse and registering bewilderment.

And the title to the picture reads "Get below the surface when you want what you want." If you're bewildered on commutation—get below the subjoined Morganite trademark (just about an inch due south of here), and you'll find the name of a brush engineer who will dig below surface appearances and prescribe the right Morganite brush to make operators feel that after all, perhaps life is worth while.

Morganite Brush Co., Inc.

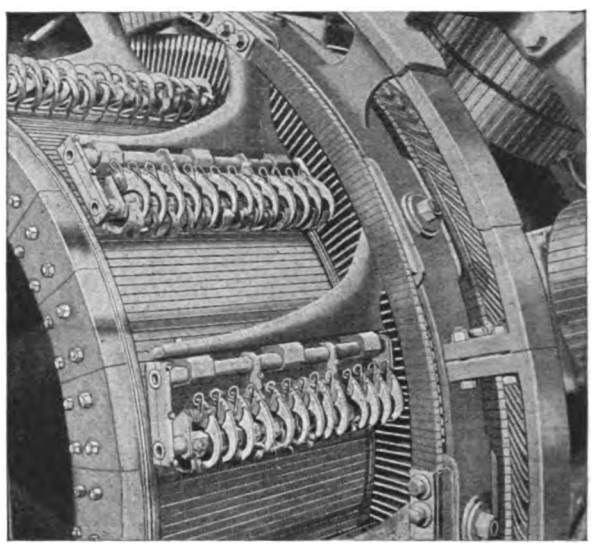
Main Office and Factory:
519 West 38th St., New York

DISTRICT ENGINEERS AND AGENTS:

Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn. Ave.
Cincinnati, Electrical Engineering & Mfg. Co., 607 Mercantile Library Bulding.
Cleveland, Electrical Engineering & Mfg. Co., 422 Union Building.
Buffalo, Electrical Engineering & Mfg. Co., 409 Lafayette Building.
Philadelphia, Electric Power Equipment Corp., 412 North 18th St.
Baltimore, O. T. Hall, Sales Engineer, 1926 Edmondson Ave.
Revere, Mass., J. F. Drummey, 75 Pleasant Street.
Los Angeles, Special Service Sales Co., 502 Delta Building.
San Francisco, Special Service Sales Co., 202 Russ Building.
Toronto, Can., Railway & Power Engineering Corp., Ltd., 131 Eastern Ave.

HERE IS THE OFFER

That has made customers for us



Let us equip a generator or motor for you with

Reaction Brush Holders

—their final acceptance will be subject to your approval after any reasonable period of operation!

They keep your commutators from running hot.
They eliminate destructive sparking.
They keep brushes from wearing grooves.
They make quiet running machines.

SAVE MONEY—take advantage of this offer today—NOW!

The Baylis Company

50 Nelson Street, Bloomfield, N. Y.

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Emergency Service

WHEN your motor or generator fails because of brush trouble—when you need brushes on short notice for any reason—

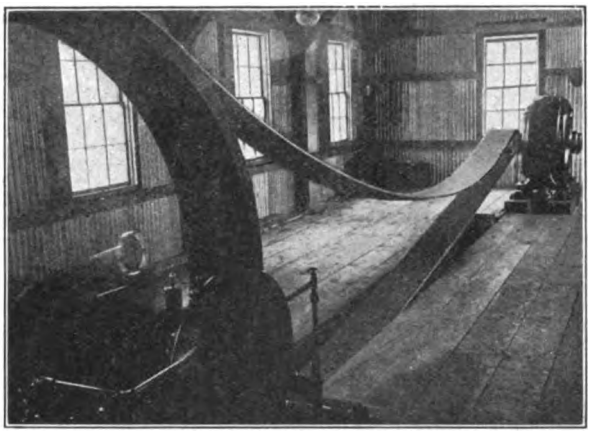
Write—Phone—Wire

to our nearest brush plant for *immediate* service.

NATIONAL CARBON COMPANY, INC.
CARBON PRODUCTS DIVISION

New York, N. Y.	*Cleveland, Ohio*	*Chicago, Ill.*	*Pittsburgh, Pa.*
237 East 41st Street	P. O. Box 400	560 West Congress Street	7th Floor, Arrott Power Bldg., No. 3 Barker Place
Phone: Vanderbilt 10471	Phone: Lakewood 4000	Phone: Harrison 0143	Phone: Smithfield 0740-0741

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A 14" leather motor belt transmitting 100 H. P. while running 31 inches slack. NO SLIP! First treated with Cling-Surface in 1912.

Slack Belts Give Full Power--

Tight belts take a toll from production that is as unnecessary as it is inefficient. This toll must be reckoned with when combating the wastes of production. It is far-reaching,—including losses of power from friction and the necessity of overcoming the increased dead load; a further drag on the pulleys that heats bearings and adds to lubrication costs; a shortening of the life of expensive belting.

Slack belts give full power, and prevent these wastes. Slack running belts, smooth running belts, steady running belts,—these are the conditions that will result from Cling-Surface treatments. And only from Cling-Surface treatments will these conditions result. It is a fact that no other treatment nor method has given results equal to Cling-Surface in the past *27* years.

Today, tension in the form of tight belts has no place in any well ordered plant. Tension has no other use than to try to prevent belt slip; in no case is it ever entirely effectual in its prevention. Why then suffer the evil effects resulting from tension when a little Cling-Surface stops slipping absolutely?

The lubricating qualities of Cling-Surface make belts mellow and pliable; its preservative qualities make them strong, durable and waterproof. There is imparted to the surface of the belt a clean, clinging, cohesive grip, while to the fibres of the belt is given renewed life and vigor. That is the action of Cling-Surface,—the action of a **pure belt food** and not just a superficial dressing.

Actions speak louder than words. Let us send you a tin on trial. Put Cling-Surface into action. When you get results, you may act on our invoice.

Clip and Mail NOW

Cling-Surface Company

1020 Niagara Street, Buffalo. N. Y.

Gentlemen—You've got me interested in your Slack Belt Treatment. Send us a trial 3 or 5 gallon

Name: ..... tin of ☐ Light

Company: ..... ☐ Medium

Address: ..... ☐ Heavy

CLING-SURFACE

(Check square ☐ for consistency desired) I.E. 12-23

1-gal. tin..$3.50 ea. 3-gal. tins..$3.40 gal. 5-gal. tins..$1.25 gal.

Be sure to see the February 1924 issue

A Special Number

ON NEW

INDUSTRIAL EQUIPMENT

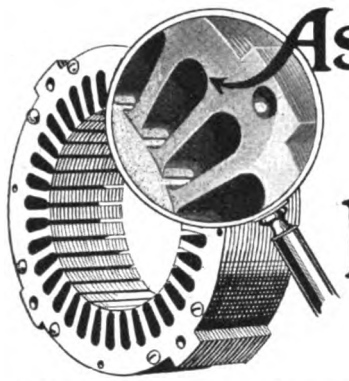
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January 20th

INDUSTRIAL ENGINEER

Old Colony Building *CHICAGO*

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As Smooth as Gun Barrels

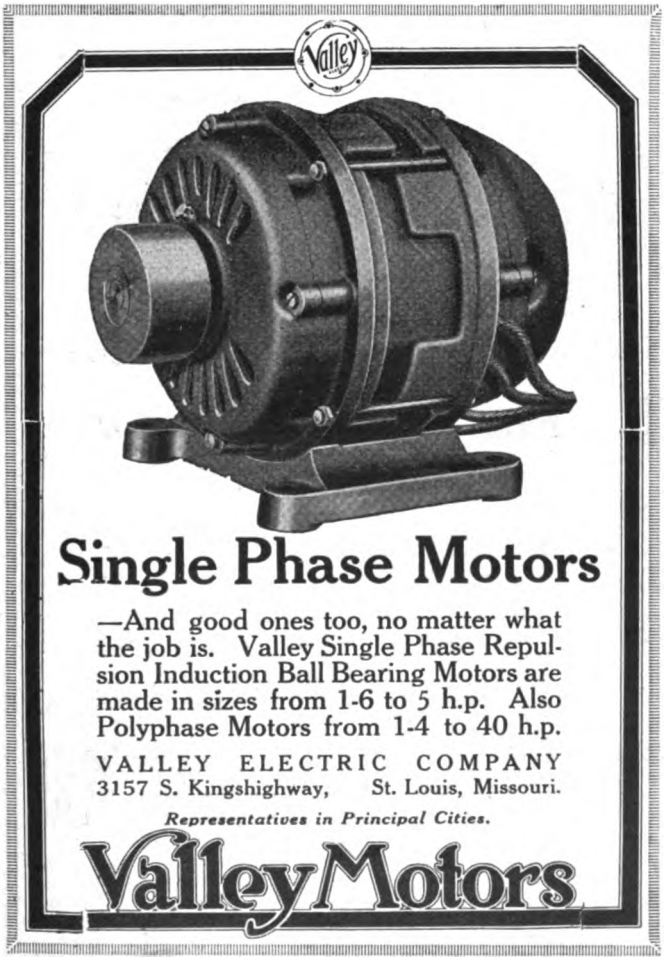
Dependable Insulation is one of the reasons for the trouble-free service given by Master Repulsion Induction Motors. The slots in Master stator cores are as smooth as gun barrels. The windings are *completely* enclosed in double-thick compartments of Fish Paper and Empire Cloth. All conductors have sleeves for extra protection.

Seven times every Master Motor receives breakdown tests of from 1,100 to 1,500 volts. A most thorough impregnating process insures windings that are moisture resisting.

If you buy motors for application on your product or for individual drive in your plant, Master Motors can save you money. Write today for detailed information.

THE MASTER ELECTRIC CO.
450 First St. Dayton, Ohio

MASTER
40° MOTORS ⅛ to 1½ H. P.



Single Phase Motors

—And good ones too, no matter what the job is. Valley Single Phase Repulsion Induction Ball Bearing Motors are made in sizes from 1-6 to 5 h.p. Also Polyphase Motors from 1-4 to 40 h.p.

VALLEY ELECTRIC COMPANY
3157 S. Kingshighway, St. Louis, Missouri.

Representatives in Principal Cities.

Valley Motors

—the Ideal is not found in Nature

We have to make it up specially, and in this way only can we know and guarantee its uniform quality. The use of lubricants on bearings is no more a necessity than the use of the Ideal on the commutators or slip rings. Both are subject to wear, and neglect is serious in either case. A few moments daily with the Ideal saves many hours and much trouble and expense for major repairs if the commutators are neglected. Demonstrate this to your own satisfaction at our expense. Use the coupon below.

IDEAL COMMUTATOR DRESSER CO
5341 N. Western Ave. Chicago, Ill.



free trial offer

Ideal Commutator Dresser Co.
5341 N. Western Ave., Chicago.

Gentlemen: Please send me an Ideal Commutator Resurfacer for free trial. If I like it I'll pay for it. If I don't like it I will return it—the trial will have cost me nothing. I want to use it on equipment as follows:

Approx. R. P. M.....Diameter of Commutator or Ring.....

Approx. width of Commutator or Ring surface.....

Approx. distance between brush sets.....Condition.....

Collector Ring or Commutator material.....

Name..... Position.....

Company.....Company Address.....

City..... State.....

12-1-23

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FAIRBANKS-MORSE



ball bearing motors

Motor failures, due to bearing trouble, practically eliminated. The bearings last as long as the motor. Positively dust-proof. Need lubrication but once a year. Reduce power bills, cut production costs

FAIRBANKS, MORSE & Co.
CHICAGO *Pioneer Manufacturers of*
ball bearing motors

244

A Holiday Gift

That he is sure to appreciate—a year's subscription to "Industrial Engineer."

Send us his name and address and $2.00 — we'll do the rest.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Old Colony Bldg. Chicago, Ill.

Burke Type E M Induction Motor



Put a Burke Motor Anywhere

Burke Motors can be adapted for service any place and in any position. They can be suspended from side walls or ceilings by merely turning the bearing brackets. They have been applied by thousands in every industry where reliable electric drive is required. Ask for particulars.

We also manufacture Alternators, Generators, Motor Generator Sets, Arc Welding Equipment and Transformers.

BURKE ELECTRIC CO.
ERIE, PA

Sales Offices: Buffalo, Cleveland, Detroit, Erie, New York, Philadelphia, Pittsburgh. Sales Agencies: Underwood Electric Co., Cincinnati; W. T. Osborne, Kansas City; Coast Equipment Company, San Francisco, Cal.

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How to keep motors on the job—longer

That's what we started to find out when we went into the field to get first-hand facts before designing Type AA Reliance Induction Motors. Twenty-five electrical engineers in ten lines of industry showed us just what weak spots were revealed in their plants. They told us what induction motors must stand and what from their experience was necessary to overcome their difficulties.

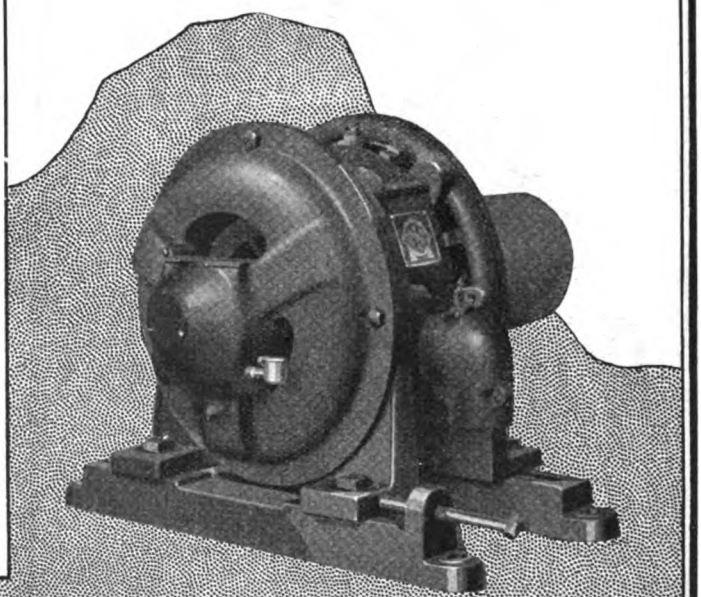
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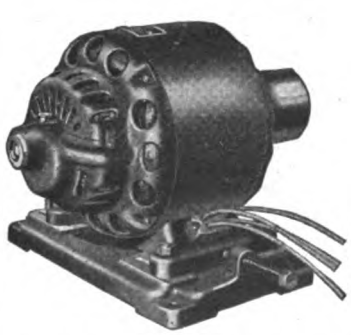
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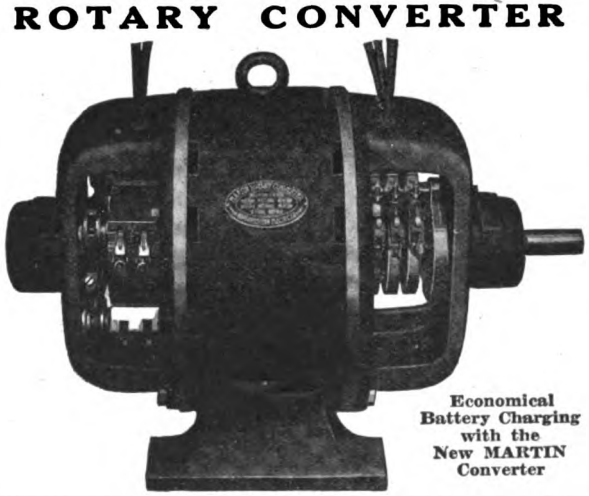


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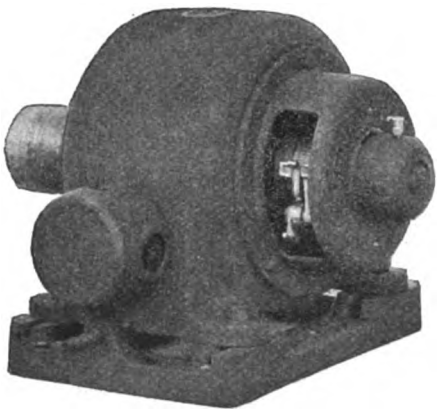
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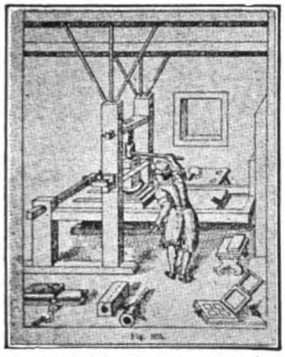
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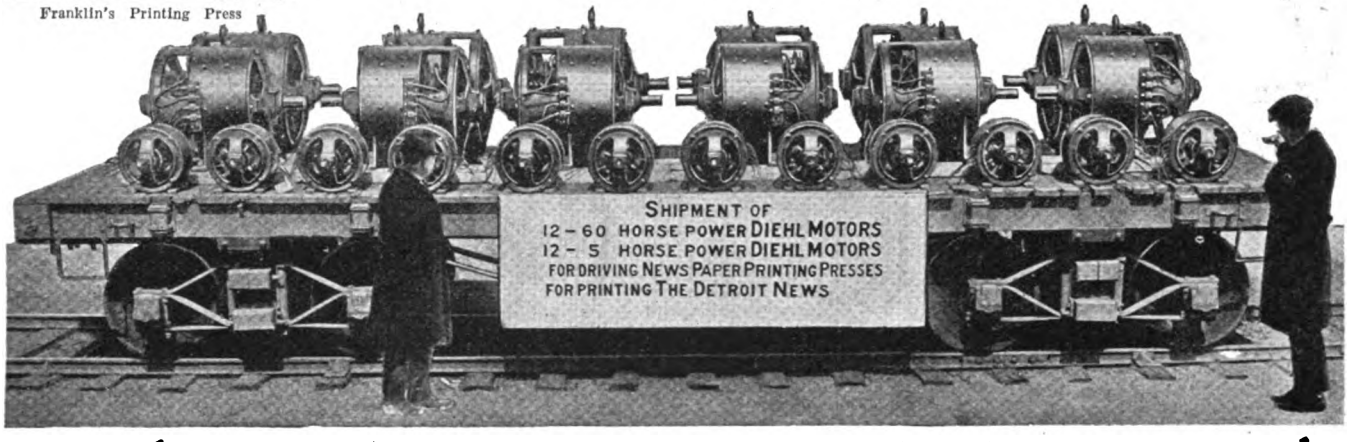
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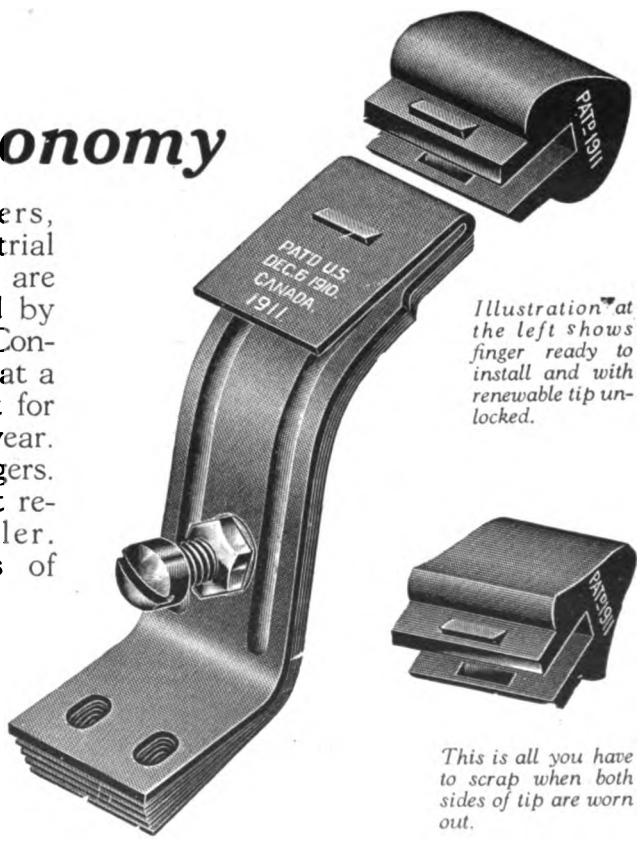
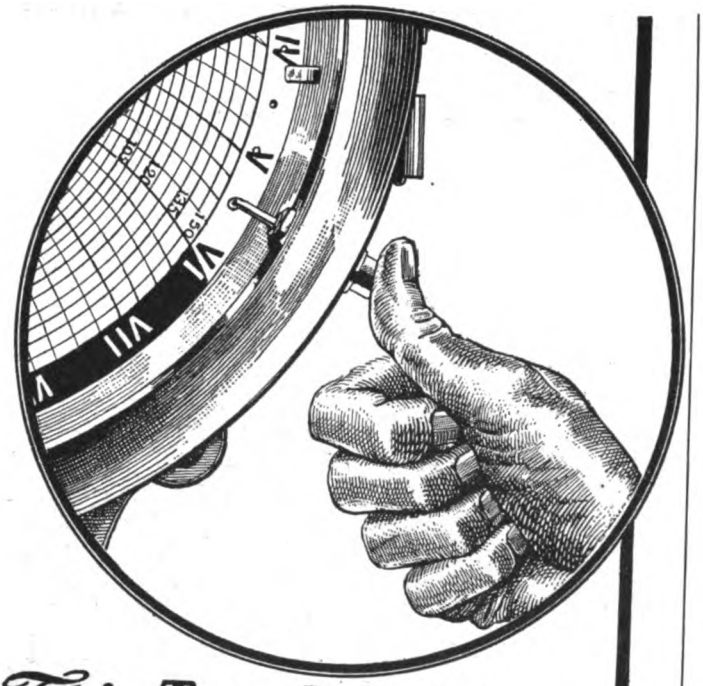


Illustration at the left shows finger ready to install and with renewable tip unlocked.

This is all you have to scrap when both sides of tip are worn out.

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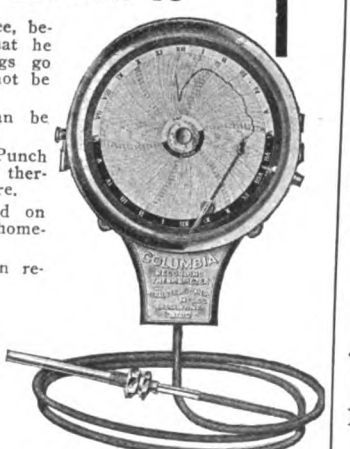
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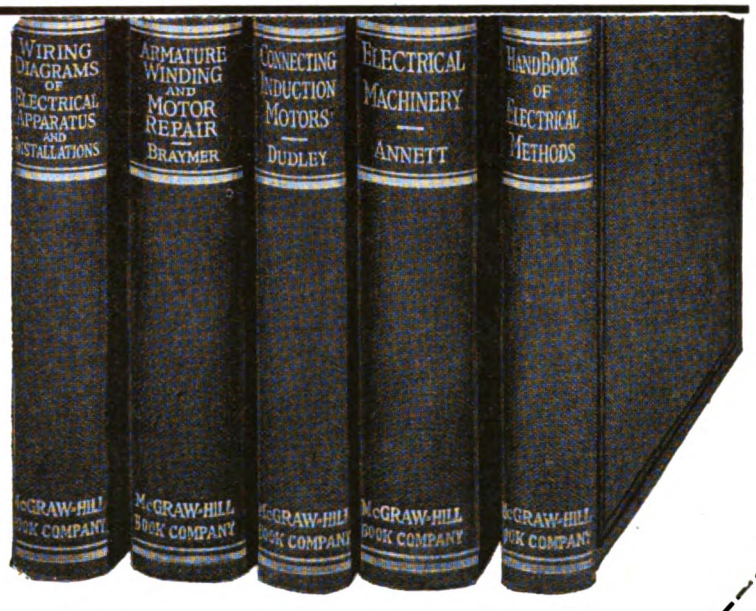
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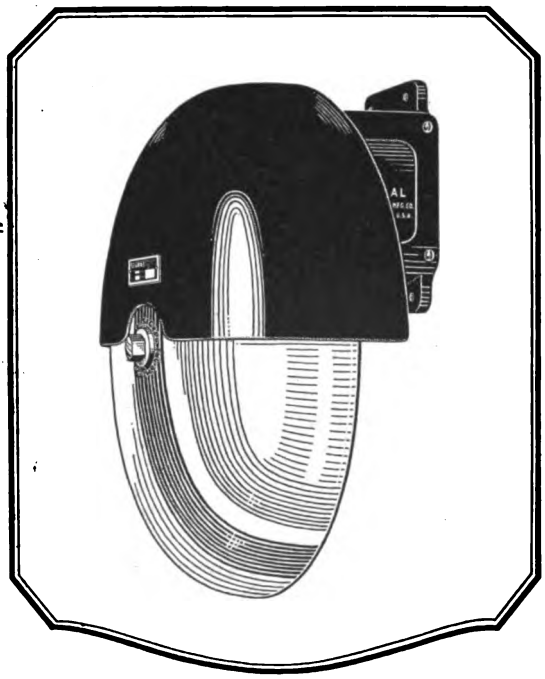
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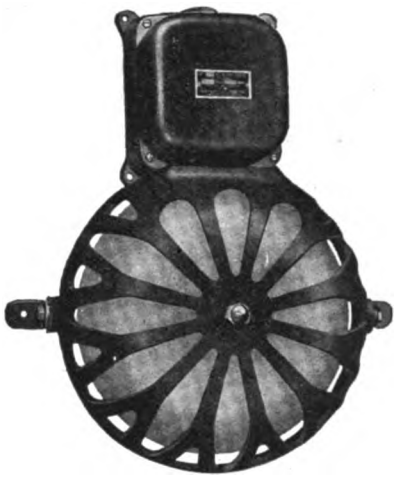
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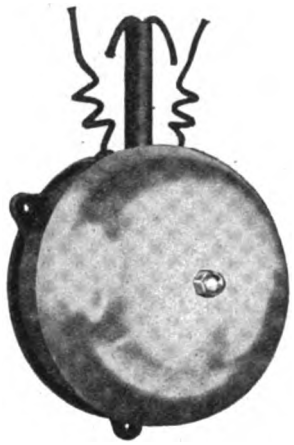
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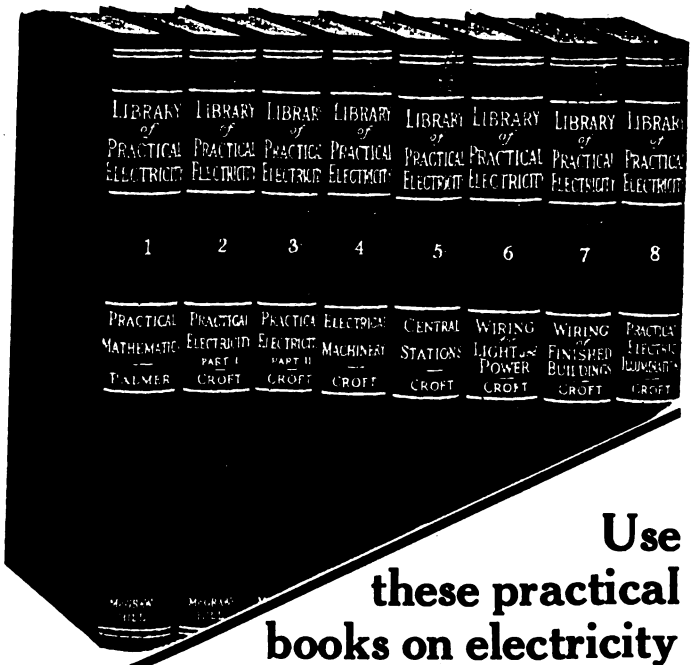
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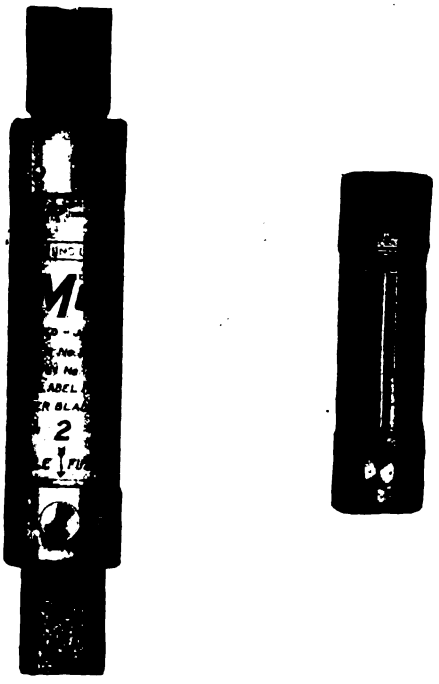
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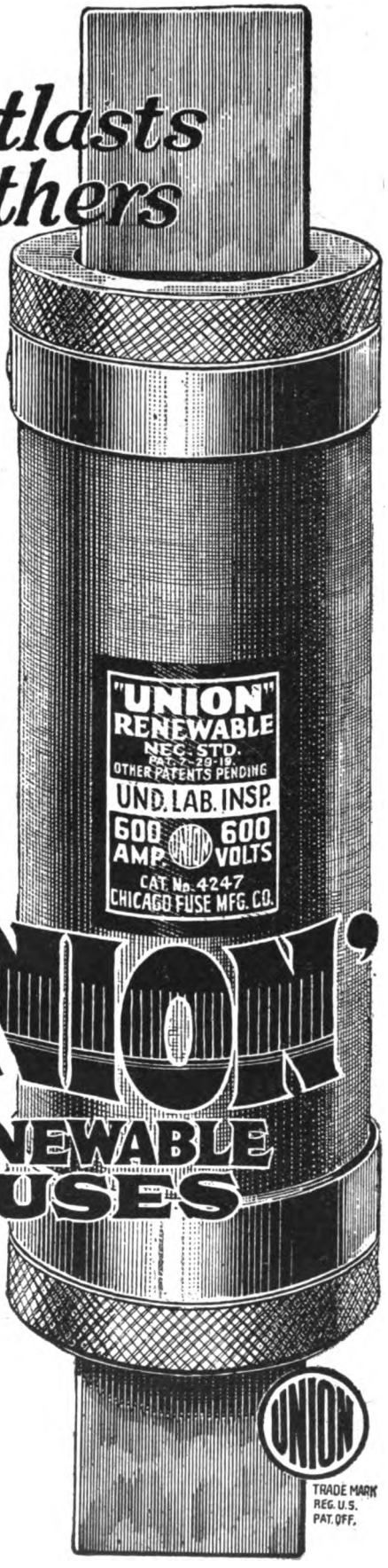
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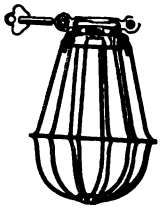
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Both science and experience have demonstrated that Cooper Hewitt light, by reason of its peculiar **quality,** has about twice the **seeing** power of ordinary electric light of the same **candle** power.

You don't need a "meter" to tell what kind of light is best for the workman—his output gives the information you want.

Cooper Hewitt light gives full daylight results in all cases—in some cases better results. Don't be mislead by "candle power" or "foot candle" measurements.

Fads may come, and fads may go—

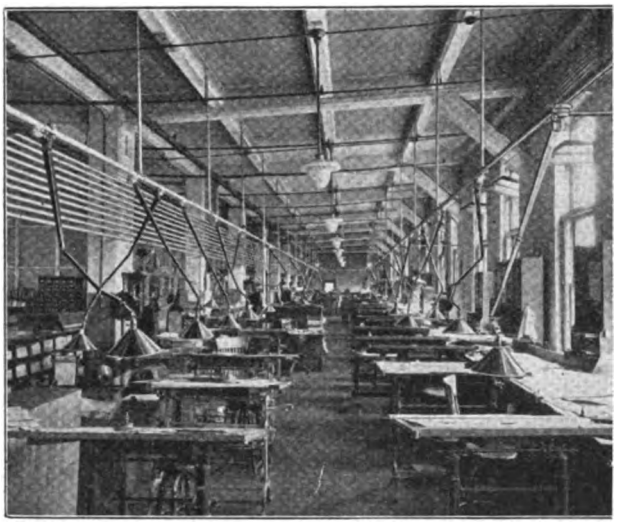
But the true artistic effects produced by Cooper Hewitt light are always in demand by the conservative public, which is the mainstay of your profession.

Cooper Hewitt Electric Company

Hoboken New Jersey

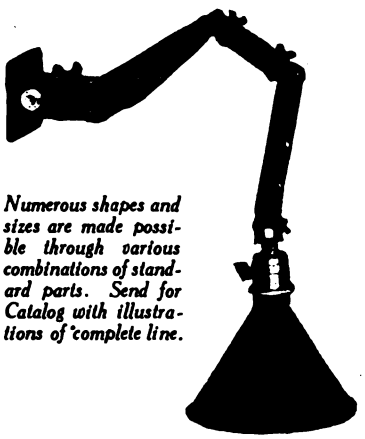
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There are 60 "American" Fixtures in this drafting room of the Allis-Chalmers Mfg. Co. at Milwaukee

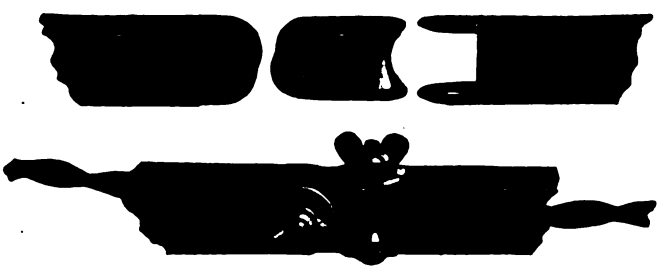
Adequate Lighting Is as Important as Adequate Lubrication



Numerous shapes and sizes are made possible through various combinations of standard parts. Send for Catalog with illustrations of complete line.

Consider how necessary to profitable operation is the smooth, quiet running of machinery, earning power and keeping down wear. Then think how much easier the human part in production is made, when eyestrain and glare are removed, and workman can proceed with ease and certainty with their work.

American Fixtures, as an adjunct to equal lighting, provides intensive illumination where it helps most.



Patented universal joint used in all "American" fixtures. Permits unlimited adjustment and cannot injure the cord.

AMERICAN FIXTURE COMPANY

232 West Water Street

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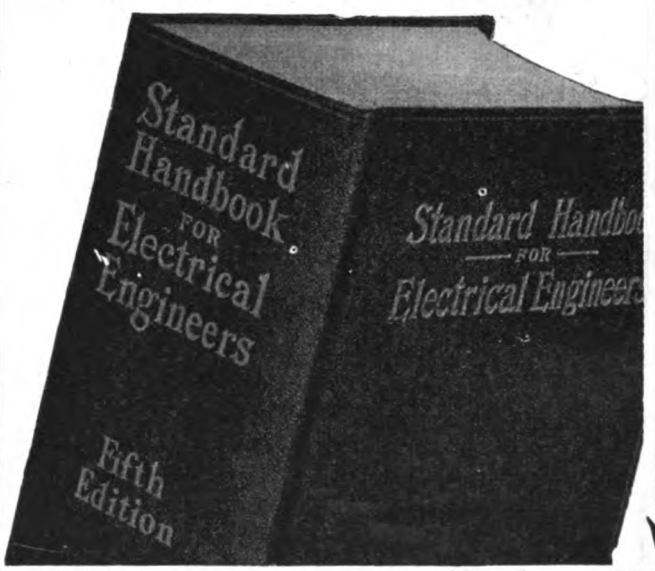
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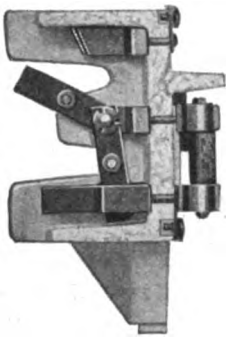
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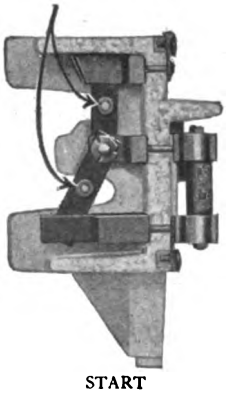
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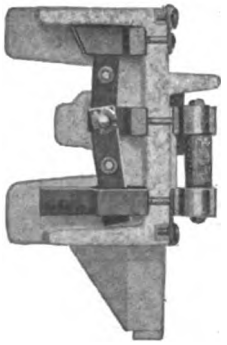


Safety at the start

means better service always


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RUN

Here is a simple, yet superior and inexpensive starting device for three phase squirrel cage motors up to 5 H. P., 250 volts. Rugged, yet easily operated, low priced, yet good looking, it forms an attractive and reliable attachment to the finest motor driven machine.

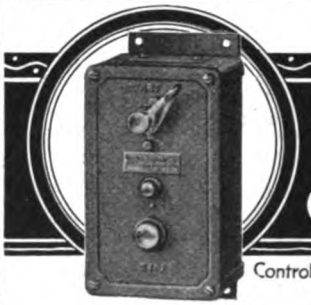
No separate main line switch is required with this starter, which is complete in itself, and capable of rendering 100% production. The fuses are dead when the door is open, providing absolute safety in replacing fuses.

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Agents in All Principal Cities



Class 8605 Automatic Compensator

Control Station

Safeguards Operator— Protects Machinery!

Operator just pushes lever—then smooth, steady acceleration—never too fast or too slow—no needless wear and tear on gears and belts with the I-C Class 8605 Automatic Compensator with time element control station.



Adjustable starting period—5 to 25 seconds. Remote control provides convenient operation of machine, wherever installed. Simplified wiring. Low voltage protection; also overload protection. Absolutely dependable.

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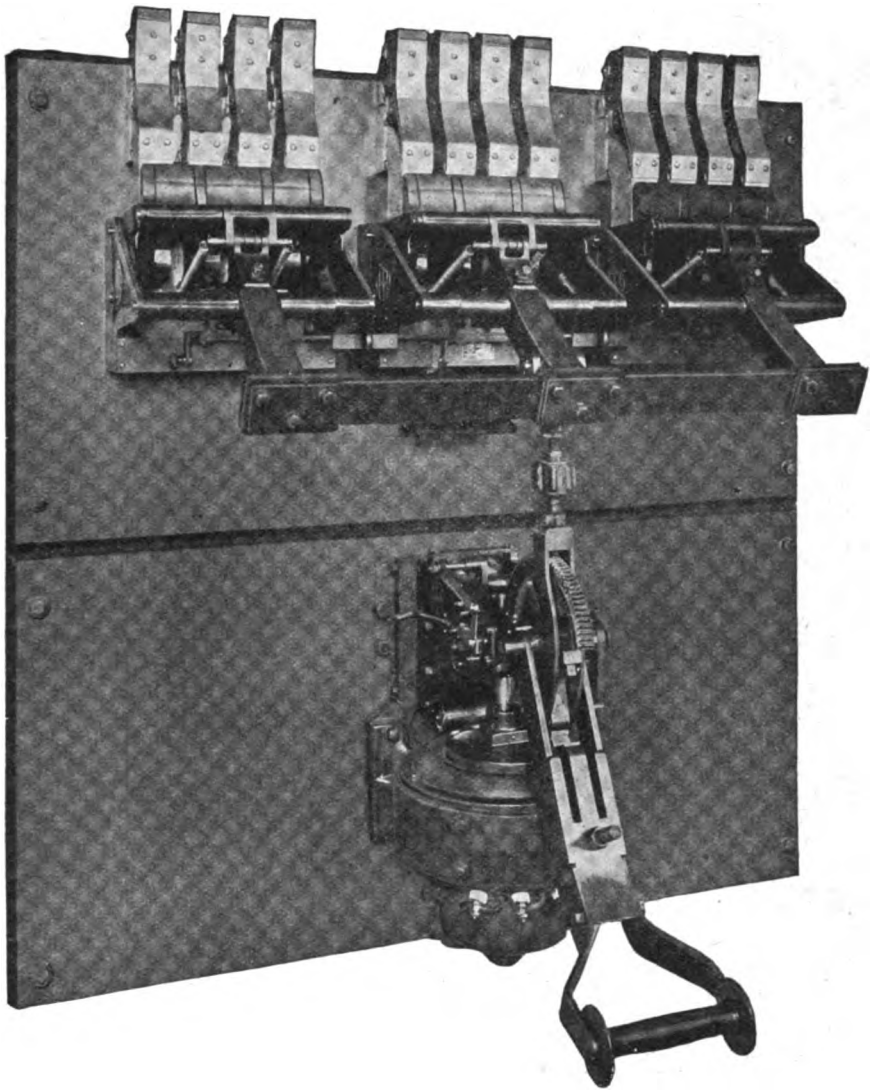
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Push Button and Lever Switches

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at 550 volts alternating current

has definite advantages not present in the oil breaker.

There is no oil to explode or leak away.

The working parts are at all times visible, making inspection not a matter of time and money.

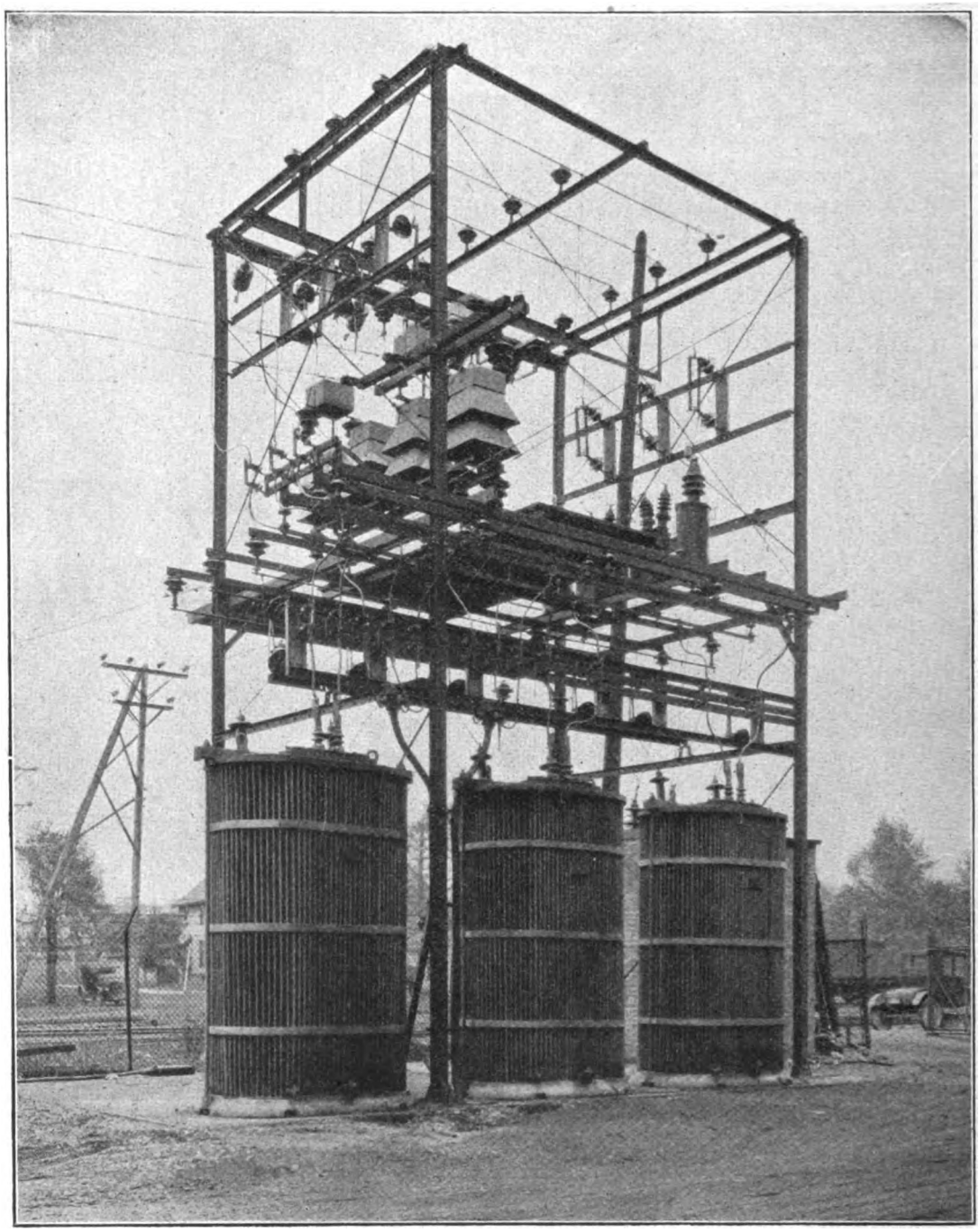
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Has series overload coils, direct action, no relays.

For large capacities we recommend motor rather than solenoid actuation.

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ESTABLISHED 1888 PHILADELPHIA
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Continuity of Power Supply

and Continuity of Operation go hand in hand.

Installation of PACKARD Transformers is the best insurance against interruption of service and cannot wisely be overlooked.

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3—PACKARD ELECTRIC POWER TRANSFORMERS—Type A, 100 KVA, 22000/16500 volt primary and 2300 volt secondary, 55 degrees C rise, 1 phase, 60 cycle, with oil. All in A-1 condition. Good as new. Write Follansbee Brothers Company, Pittsburgh, Pa.

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4 cents a word.
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ELECTRICAL SUPPLY JOBBERS AND ELECTRAGISTS
MOTORS SOLD—RENTED—REPAIRED—EXCHANGED

Direct Factory Representatives of

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Largest Stock of Used Electric Motors in America

220 Volt D. C. Motors

HP			Speed	HP			Speed
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1	2	G. E., RC-26A, interpl	850	7	10	G. E., type RF-10A, shunt, interpole, adjustable speed	600-1800
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1	3	Crocker-Wheeler, form L, comp.	1800				
1	3	Westinghouse, type S, comp.	1800	2	10	Westghse., type SA-7, shunt, interpole, variable speed	400-1600
1	3	Robbins & Myers, comp.	1750				
1	3	G. E., RC-25, interpole	1700	3	10	Northern, back-geared, 28 to 8	800-278
1	3	Robbins & Myers, comp.	1100	2	11	Westinghouse type SK-90, interpole adjustable speed	450-1800
1	3	Western Elec., type E	1025				
1	3	Crocker-Wheeler	975	1	12½	Fairbanks-Morse	1400
1	3	G. E., RC-27A, interpole	850	1	13	Crocker-Wheeler	1100
1	3½	Triumph, comp.	910	1	15	G. E., type RC-29-A, interpole	1700
1	3½	Westghse., SK, comp. interpole	850	1	15	Allis-Chalmers, type K	1450
1	4	Crocker-Wheeler	1170	1	15	Peerless	1200
1	4	Milwaukee	1000	1	15	Robbins & Myers	1050
1	4	Roth, comp.	700	2	15	G. E., type CVC, interpole	925
1	4	Allis-Chalmers, type N	575	3	15	Northern	800
1	5	G. E., type RC, interpole	1900	1	15	Electric Machinery	800
7	5	Cr.-Wheeler, form L	1750	1	15	Allis-Chalmers, type K	800
1	5	Westinghouse, type SK, interpole	1700	1	15	G. E., type RC-11, comp., interpole	800
20	5	G. E., type RC-26A, interpole	1700	1	15	Triumph, comp.	650
1	5	Peerless, comp.	1300	2	15	G. E., type CQ	625
1	5	Ft. Wayne	1300	1	15	Westinghouse, type SK-100L, interpole, adjustable speed	500-1500
1	5	G. E., type RC, interpole	1150				
2	5	Sprague (G. E.), LC, comp., interpole	1150	1	15	Electro-Dynamic, interpole, variable speed	450-1350
1	5	G. E., type CQ	1100	2	15	Westghse., type SK-110L, interpole, adjustable speed	400-1600
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Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here

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Bells, Electric
Schwarze Electric Co.
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Belt Lacing Machines
Detroit Belt Lacer Co.

Belts, Conveyor
Link-Belt Co.

Belts, Transmission
Link-Belt Co.

Bench Drawers, Steel
Lupton's Sons Co., David

Blow Torches
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Clements Mfg. Co.
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Chicago Expansion Bolt Co.
Paine Company
Toggle
Chicago Expansion Bolt Co.
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General Electric Co.
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Brackets, Instrument
Trumbull Electric Mfg. Co

Brakes, Electric
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg Co.
Crane
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Calebaugh Self Lubricating Carbon Co.
Jeandron, W. J.
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Baylis Company
Flower, D. B.

Buffers
Cleveland Arm. Wks.

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Bushings
Appleton Electric Co.
Porcelain
Thomas & Sons Co., R.

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General Electric Co.
Westinghouse Elec. & Mfg. Co.

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Diamond Metal Co.

Cement, Commutator
Early Co., Edward E.
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Link-Belt Co.

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Rome Wire Co.
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Has anyone disproved this:—

A bad ending follows a bad beginning

—Euripides

A lot of wise ones have come and gone since Euripides placed these words before a critical public in 456 B. C.

Read them again: "A bad ending follows a bad beginning"—and remember them, because sooner or later you will have to buy Safety Switches—and perhaps you'll want safety *in* switches.

Far be it from me to say what you won't get at the start in other switches.

But you *will* get a good beginning in the Circle T.

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When you're thinking through the subject of Safety Switches, be sure you're right at the start—before you go ahead—make the good beginning—start with the SWITCH every time for that's the part that has to do the work.

If you'll do this—and it's the perfectly logical thing to do—then I'll feel that the Circle T cause is safe.



★This book treats (a) on the Safety Switch IDEA—(b) on the principles involved and (c) on the largest line of safety switches you can afford to use.
We want you to have a copy—gratis.

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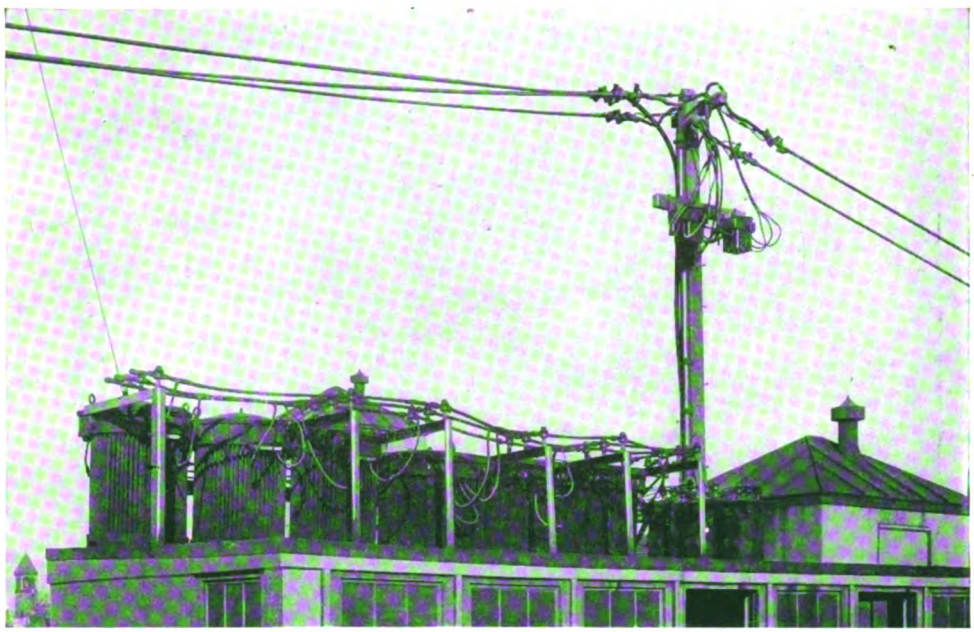
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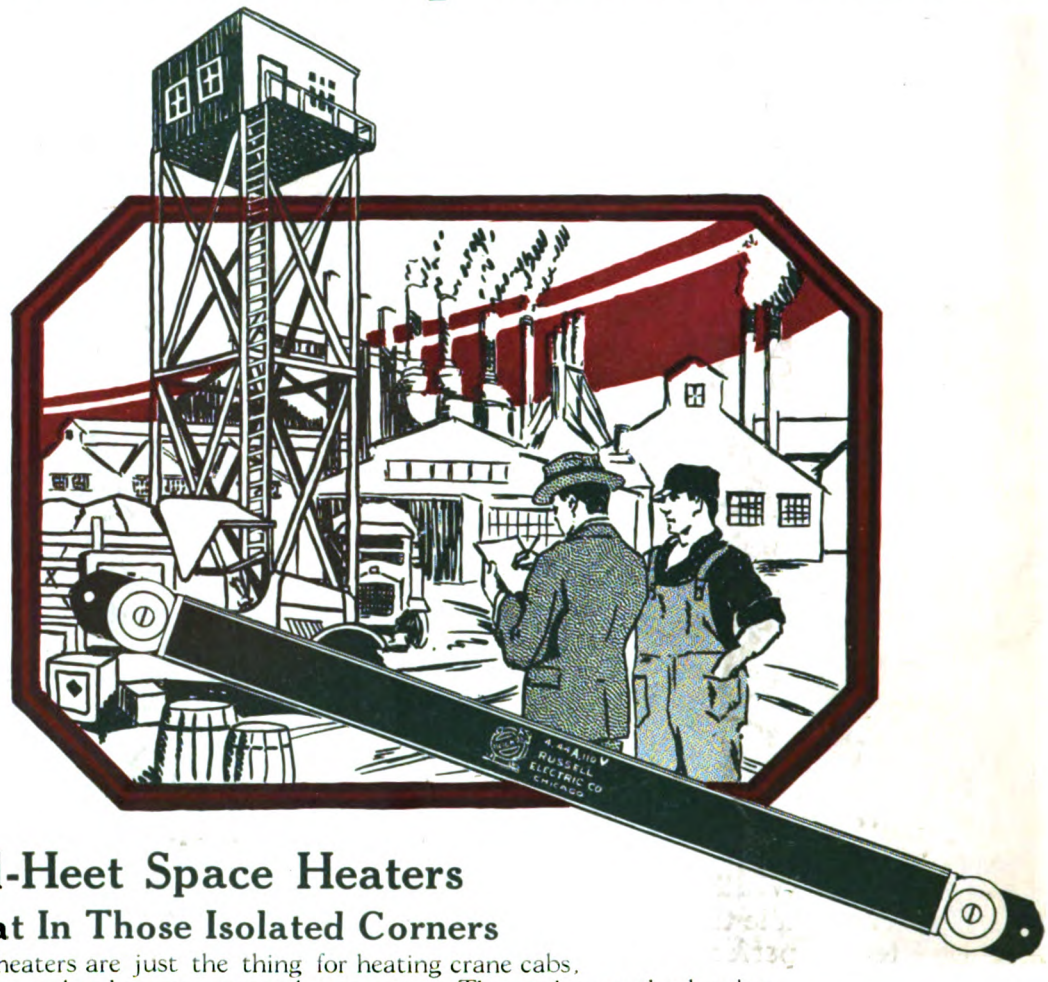
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The Superior Hold-Heet Construction will solve your heating problem quickly and economically. We manufacture thousands of special type heaters. Send us your inquiries.

Quickly and Easily Installed

Simplicity of installation makes these heaters easily adaptable to any heating problem. Each unit is an independent 500 watt heater with $22\frac{3}{4}$" mounting centers—24" overall. Add as many as you require to deliver the proper heat.

Low In Cost—Durable and Trouble Proof—Fully Guaranteed

A better and more highly developed patented method of manufacture has increased production and lowered costs. Every bit of material used is the best the market affords. The result is a product of exceptional ruggedness and durability. A trial order will convince you of Hold-Heet superiority. Every heater is guaranteed unconditionally for one year and will be replaced free of charge if unsatisfactory for any reason.



Shipments Made Day Order Received

Prompt shipments in any quantity. Your order for standard heaters goes out the same day as received. Standard 500 watt heaters supplied for 110, 220 or 250 volts.

We Deliver Standard Heaters Prepaid Anywhere in U. S. A. at These Prices

Less than standard package	**$2.50** each
Standard package (10 heaters)	**$2.25** each
Lots of 100 or more	**$2.125** each

Russell Electric Company

The world's largest manufacturers of electrically heated devices

340 W. HURON STREET **CHICAGO, ILLINOIS**

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